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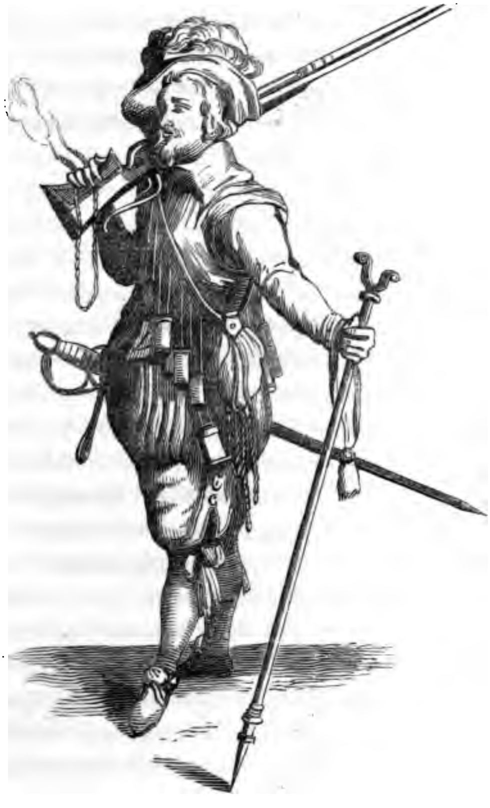
AND

EXPLOSIVE COMPOUNDS.



ANCIENT MUSQUETEER.

PROJECTILE WEAPONS OF WAR

AND

EXPLOSIVE COMPOUNDS.

BY

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PREFACE.

It may be proper to inform the reader that these pages are the Second Edition of a *brochure* published in 1845, and the fate of which was unusual. Immediately on being announced for publication, the whole stock, with the exception of about a dozen copies, was purchased by the agent of a foreign State, and exported—so that it never found its way into British literary commerce.

As the peculiar circumstances under which Great Britain is now placed have created a desire on the part of many to be made acquainted with the nature and qualities of arms of fire, I have been induced to publish this Second Edition.

Since 1845 the development of fire-arms has been very great. The improvements of Minié, Delvigne, and others, on rifle projectiles; the practice of oval rifle-boring by Lancaster; the celebrated needle gun of Prussia, were all that period either unknown, or an acquaintance with their principles limited to a comparatively few.

A similar remark may be made as respects the revolving or repeating fire-arms of Colonel Colt, and the rifled rocket of Mr. Hale. All these topics are brought up to the condition of the present era, and the chapter on rifle-guns has been entirely re-written.

In saying that this little volume is altogether devoid of military technicalities, I take no credit to myself. Being totally ignorant of military evolutions—and even military terms, I could not well do less. My object has been, in these pages, to regard arms of fire as so many varieties of philosophical instruments, embodying and illustrating chemical and mechanical laws; to demonstrate their powers, and develop their principles. If I have succeeded to this extent, I shall be content; and in any case, I shall have the satisfaction of feeling that the task was not undertaken without the presumptive justification of having devoted the leisure hours of many years to the practical consideration of fire-arms, and their effects.

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PROJECTILE WEAPONS OF WAR

AND

EXPLOSIVE COMPOUNDS.

THE intellectual qualifications which raise man far above all other animals, have never been more industriously exercised than in perfecting the art of war; so that whilst the lion and the tiger are still obliged to meet their enemies at close quarters, and savages, by their rude missiles, scarcely gain a point in civilization, we, of more refinement, bring to the conflict every accessory of modern science, and kill our foes according to the most approved laws of mathematics and chemistry. The Utopian may shrink from the contemplation of so painful a subject; the moralist may raise his voice against the justice of war; but the practical philosopher can see very little chance of its cessation, and, actuated by the very best intentions, will endeavour to render warfare as terrible as possible, well knowing that so soon as certain death awaits two rival armies, princes must fight their own battles, or wars must cease.

Amongst the many improvements in the art of war, those relating to missile weapons, by which men are slaughtered at a distance, afford the greatest scope for scientific investigation, and are of the greatest interest to general readers. This interest, too, is greatly enhanced by the general formation of volunteer rifle clubs, in anticipation of an event which, although we all trust it may not occur, should nevertheless be provided against.

Such being the state of public feeling on this topic, we purpose giving an account of military projectiles in general, and especially those which are urged by the ignition of explosive compounds.

It would be impossible justly to appreciate the value of explosive compounds in their particular application to the launching of projectiles, without devoting some attention to the means and appliances generally had recourse to anterior to the period of their introduction. We intend, therefore, to give a slight sketch of the nature and uses of missile weapons, commencing with remote periods, and continuing to the present time. As much as possible, we will be restrained within the limits which bound the immediate subject, but occasionally those limits will be found not very definite, and we shall be obliged to merge into general history, to speculate on the moral consequences of improved systems of war, to notice varieties of defensive as well as offensive arms, to describe occasionally the manufacture of warlike implements, more particularly those to which present interest is attached, such as the Congreve rocket and percussion shell,—all this, and much more of interest, lies so near our prescribed bounds, that we shall not hesitate to avail ourselves of it, merely because the title of our dissertation may be slightly violated thereby.

Man's first rude attempts at missile weapons were doubtless limited to the throwing of sticks and stones, by the mere aid of his hands; acts in which the monkey, the bear, and even the seal, are very successful emulators. A desire of more successful aggression doubtless soon suggested to man the use of projectiles more efficient than these. By a very slight change of form, the simple stick would become a javelin, capable of being hurled with great force and precision. An aid would suggest itself for casting a stone by means of a fillet or band, subsequently denominated the sling. Lastly, as involving a little more of mechanical contrivance, would be invented the bow; which, in process of time, by subsequent additions, would become the arbalest, or cross-bow.

By the time portable weapons would have been brought to the perfection just indicated, man's increasing sciences and civilization would have led him to build cities and enclose them with walls. Now would arise a necessity for other projectiles of greater force, inasmuch as in the event of war these walls would have to be demolished. The transition from portable projectiles to those of a heavier class was obvious enough; enormous javelins and darts were hurled by cross-bows of corresponding size, termed catapultæ; and engines having the sling for their model, and hurling enormous stones, were termed balistæ.

This appears to be the proper distinction between the two terms, although, by many persons, they are spoken of as synonymous. A variety of warlike missile engines were in use besides these, and called by the most fanciful names; however, the balista and catapult may be considered as the types of all the rest; except, indeed, those which were adapted to particular localities or extraordinary occasions, when the number and variety of engines were only limited by the engineer's constructive skill.

In the prosecution of our subject, we shall first describe the various portable missive weapons which have been used in different nations, and then direct our attention to those of a larger class, such as would *now* be denominated *artillery*—a word, by the way, which originally signified *archery*.

The first missive weapon we shall notice in detail is the JAVELIN, or dart, variously modified, and known under several names.

The ancients were well acquainted with this weapon. In the Scriptures we have frequent notice of it, and every one is aware how extensive was its employment by Homer's heroes. In order to perfect the practice of this weapon, the ancients instituted javelin matches, constituting a part of what the Romans called their "jaculations." According to Plato,[*] there were two sorts of jaculations; the first he called *τοξικην*, and the latter *ακοντισμα*; the Latins translated the first word by "sagittatio," and the second by "jaculitio." Only the latter would appear to refer to the throwing of javelins, the former term having reference to the action of a bow. It would appear that the javelin used on horseback was about five feet and a half long, and that the steel with which it was headed was usually three-sided, but sometimes round. In order to launch it with greater force, it was not propelled by the unaided arm, but by the assistance of a thong fastened to its butt end.

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[*] *De Leg.*, l. viii.

Such was the javelin employed by the Greeks and Romans on horseback, and for the most part in their games; but the Roman infantry possessed a much more efficient weapon of the javelin kind, termed *pilum*. Of these weapons every man of the legionary soldiers carried two, which he hurled against an enemy in the charge. Polybius mentions that the point of this weapon being very long and small, was usually so bent at the first discharge as to be rendered useless afterwards. This was not an imperfection, but a necessary quality, lest the enemy might use it in his turn. Accordingly, we find that Marius was considered to have greatly improved this instrument, when, during the Cimbrian war, he so fashioned it, that on striking the enemy's shield, it bent down at an angle in the part where the wood and iron were joined, thus becoming totally useless to the party who received it.

With every improvement that the javelin was susceptible of, it never could acquire a long range; consequently we find that as archery became developed, the use of this weapon declined. Even at the present time, however, the javelin termed "*djereed*" is used with considerable effect by certain oriental nations, who invariably employ it on horseback. It is totally unadapted, however, to the nature of regular combinations and systematic attack.

Amongst savage nations the use of the javelin is very common; but the aborigines of Australia have a manner of throwing it altogether peculiar to themselves,—not grasping it in the middle, and throwing it whilst poised at a balance, but projecting it by means of a stick applied to the butt end. This contrivance accomplishes a great increase of range, but does not contribute to the accuracy of direction. Compared with such missive weapons as we are now in the habit of using, the javelin does not appear a very efficient weapon; yet, at short distances, its penetrating force is considerable, as is learned from the act of harpooning a whale, harpoons being merely javelins thrown by hand.

These few remarks will suffice for the javelin, and we shall now proceed to treat of another very celebrated missive weapon of antiquity—the Sling.

The force with which a stone can be thrown by the unaided hand is altogether insignificant in a military point of view; several mechanical contrivances suggest themselves, however, for increasing the effect.

Amongst the most simple of these is a fillet of leather, or similar substance, broad in the middle, and tapering away towards either end. This is the common sling, which was used in the following manner:—A stone, or bullet, being placed on the broad middle part, the two ends were grasped in the right hand; then the stone being whirled violently around the head, and one end suddenly slipped, the stone flies towards an object with great velocity. The islands Majorca, Minorca, and Ivica were, it is well known, called the Balearic Isles, on account of the expertness to which their inhabitants had attained in the use of this weapon. This dexterity they acquired by constant practice, being trained to it from their infancy; their mothers placing their daily food on the top of a pole, and giving them no more than they beat down with stones from their slings. This art is in some measure preserved by the Minorquin shepherds at the present day. The Romans had slingers in their armies, for the most part inhabitants of these islands. Diodorus Siculus says that they always carried three slings, one of which they held in their hands, another being tied round their middle, and a third round their head. Such was the violence with which, in battle, they projected their missiles, that the latter seemed as though they were cast by some military engine, and no armour could resist their stroke. In besieging a town, they wounded and drove the garrison from the walls, throwing with such exactness as rarely to miss their mark.

Slings never appear to have been much used by the English, although Froissart* mentions an instance of their having been used *for them* by the people of Brittany, in a battle fought in that province during the reign of Philip de Valois, between the troops of Walter de Mauni, an English knight, and Louis d'Espagne, who commanded six thousand men, in behalf of Charles de Blois, then competitor with the Earl of Montfort for the duchy of Brittany. Froissart says, that what made Louis lose the battle was, that during the engagement the country people came unexpectedly and assaulted his army with bullets and slings. According to the same author, they were also used in naval combats. Slings were used in 1572, at the siege of Sancerre, by the Huguenots, in order to save their powder. D'Aubigné, who reports this fact, says they were thence called Sancerre harquebuses. With respect to the range of this projectile, it is said that a good slinger would project a stone 600 yards. This assertion, however, seems very doubtful.

THE BOW.—This weapon, under some shape or other, was employed by most nations of antiquity, but not always as a warlike instrument. Scarcely any two nations have made their bows exactly alike. The Scythian bow, we are told, was very much curved, as are the Turkish, Persian, and Chinese bows, at the present day; whilst the celebrated weapon of our ancestors, when unstrung, was nearly straight. All these bows, however, belong to the same class, being bent and discharged by the hand alone, without the aid of machinery. In process of time a modification of the bow was invented: in place of the original instrument, a much shorter and stiffer bow, usually of steel, was placed transversely in a stock, bent by a lever, and discharged by a trigger, after the manner of a gun. Bows of the former type were called long bows, whereas the latter were denominated cross-bows.

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* Vol. I. chap. lxxxv. p. 304.

It is not our intention to give an elaborate history of the bow, nor attempt to give the many varieties which antiquarian research has disclosed. We shall, therefore, do little more than allude to the bows and archery of ancient times and distant nations, and devote the chief of our attention to the development of this instrument in our own land. We frequently read of the bow in Scripture. The first passage in which the use of the bow is inferred is Genesis xxi. 20, where it is said of Ishmael, "And God was with the lad, and he grew, and dwelt in the wilderness, and became an archer." The overthrow of Saul was particularly owing to the Philistine archers. (1 Sam. xxxi. 3.) David, too, who succeeded him, bade them teach the children of Judah the use of the bow: "Behold it is written in the book of Jasher." (2 Sam. i. 18.)

The Greeks ascribed the invention of the bow to Apollo, by whom its use was communicated to the inhabitants of Crete; hence, in later ages, the Cretan archers were thought superior to all others. Some, however, ascribed the invention to Perses, son of

Perseus; others to Scythes, the son of Jupiter, the progenitor of the Scythians. All these tales show the antiquity of the instrument.*

The Grecian bows were usually made of wood, but sometimes of horn, and frequently, in either case, beautifully ornamented with gold and silver; the string was generally made of horse-hair, but sometimes of twisted hide, as we read of in Homer, whence the appellation *τοξαβυεια.* That part of the bow to which the string was fastened, the upper part, was called *κορωνη*, being commonly made of gold, and was the last thing towards finishing the bow.

The bow was not drawn in the same way by every nation. The ancient Persians† drew the string towards their ear, as is the practice still with the English. The ancient Greeks, however, drew the bow-string towards the breast, and represented the fabled Amazons as doing the same. Every one is conversant with the tradition of these people cutting off the right breast in order to give facility to drawing the bow.

Until the second Punic war the Romans had no archers in their armies, except those which came with their auxiliary forces.‡ Subsequently bows and arrows were more employed by this people, although, so far as we can learn, not by native troops, but by orientals in their pay.

During the reign of Clovis, who died 514, the

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* See Potter's Arch. Græc.

† Procopius, *De Bello Persico.*

‡ Potter, *ut suprà.*

French in their armies made no use of the bow, but it was employed during the reign of Charlemagne, who flourished in the beginning of the eighth century. This is undoubted, as, in an article of the Capitularies of that king, a count is mentioned who was directed, on conducting soldiers to the army, to see they had their proper arms—that is, a lance, a buckler, a bow, two strings, and twelve arrows.*

We shall not trace the progress of foreign archery any further, but come to the consideration of our own.

It is certain that both Anglo-Saxons and Danes were well acquainted with the use of the bow, an art which they derived, without doubt, from Scandinavia. In the account of the games of the heroes of that country, given by the Scalds, or Scandinavian poets, archery is frequently mentioned. It would appear, however, that both Anglo-Saxons and Danes used the bow rather as an instrument of amusement or the chase, than a warlike weapon; and for its latter application we are indebted to the conquests of the Normans. In an ancient manuscript† of the tenth century, there is represented a Saxon bow, from which it appears that its construction was not at all adapted to render it a military weapon, the string not being fastened to the extremities, but suffered to play at some distance from them. Moreover, its size was altogether that of a mere toy.‡ There is very little doubt that the bow, as a military weapon, was introduced by the Normans at the battle of Hastings; we know that Harold was shot by an arrow. No mention, however, is made of archers on the side of the Saxons.

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* P. Daniel.

† MS. Cott. Claud., B. IV.

‡ Strutt's Sports and Pastimes, p. 39.

Although we know that archers tended very materially to secure to the Normans this memorable battle, it is not yet determined whether they used the long bow or the arbalest, otherwise called cross-bow. Grose, in his Military Antiquities, states the former; general testimony, however, is in favour of the latter, and there seems collateral evidence to the same effect. We find that the English, at subsequent periods, greatly preferred the use of the long bow, so that it was considered as a national weapon; while the cross-bow was much more employed in France. Now, we may easily fancy the English gradually perfecting the old Saxon instrument, and developing from it the long bow, when they would be disinclined to use a weapon introduced by the Normans, against whom there long remained an unconquerable aversion.

The exact time when shooting with the long bow commenced, is uncertain, but its use was much extended about 1139, owing to a curious circumstance. The second Lateran Council* forbade, under the penalty of an anathema, the use of the arbalest, or cross-bow, as hateful to God, and unfit to be employed among Christians. Pope Innocent III. confirmed this prohibition. The reason of this strange decree seems to be the dangerous and painful wounds caused by this weapon; but it would require the united genius of many popes to discover agreeable methods of putting soldiers *hors de combat.* This prohibition was observed under the reign of Louis the Young, and in the beginning of that of Philippe Auguste; but afterwards no regard was paid to it, either in France or in England. Richard I., despite Innocent's injunctions, introduced the cross-bow into our armies, and being subsequently killed by an arrow-shot from one of them at the siege of the castle of Chaluz, in Normandy, his death was considered as a judgment from heaven, inflicted on him for his impiety. Notwithstanding this example, the cross-bow still continued to be much used by English troops, and in the list of the forces raised by Edward II. against the Scots, cross-bowmen are enumerated.

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* "Artem illam mortiferam et Deo odibilem balistrariorum et saggitariorum, adversas Christianos et Catholicos exerceri de cætero sub anathemate prohibemus."—*Can.* 29.

Although we know the cross-bow to have been used in the reign of Edward II., yet it would appear that about this time the use of the long bow became extended; at least, we now begin to find the word *sagittarius* (an archer), whereas he who shot with a cross-bow was termed *balistrarius.* Not only were long bows employed as well as cross-bows against the Scots, in 1323, but also in the next year, by the army sent to the relief of Aquitain. It would seem that the arbalest and the long bow had only to be used together in order to prove the vast superiority of the latter, for its extension now rapidly increased, and in the reign of Edward III. the glory of this weapon was in its zenith.

This monarch appears to have taken great pains to increase its efficiency and extend its use. In 1342, the sheriffs of most counties in England were ordered to provide 500 white bows, and as many bundles of arrows, for the intended war against France. Subsequently to this, the king again sent to the sheriffs, complaining that the practice of archery was too much neglected by the people, who, instead of shooting on Sundays and holidays as heretofore, were in the habit of amusing themselves with various unlawful games. The terrible execution effected by the English archers at the battle of Creçy, in 1346, is well known, and in this instance the peculiar genius of the weapon, and its superiority over the arbalest, were well displayed. Previously to the battle, there fell a shower of rain, which so slackened the strings of the cross-bows used by a troop of Genoese in the French pay, that the weapons became almost unserviceable, whereas the English long bows, which had been encased during the shower, were perfectly effective. It is obvious that the very shape of the cross-bow would prevent its being surrounded by a case, and here, as in many other instances, the long bow had a decided advantage.

Ten years after this occurred the battle of Poictiers, which was also won by the skill of our archers. The decisive victory of Homeldon against the Scots, in 1402, was entirely achieved by them; and the Earl of Douglas found that the English arrows were so swift, and so strong, and discharged so forcibly, that no armour could repel them; his was of the most perfect temper, and yet he was wounded in five places. The English men at arms, knights, and squires, never drew sword or couched the lance, the whole affair being decided by the archers. The archers again did terrible execution at the battle of Shrewsbury, in 1403, where Hotspur was slain; and the battle of Agincourt, in 1417, was their undivided conquest. So many victories accomplished by the employment of our favourite weapon, would, it might be supposed, have induced the enemy to imitate us; nevertheless, this does not seem to have been the case; the French pertinaciously adhering to the employment of the arbalest; for which reason Henry V., as Duke of Normandy, confirmed the charters and privileges of the *Balistrarii*, who had been long established as a society at Rouen. When we come to consider the long training, strength, and address necessary to constitute a successful archer, we need not wonder that the practice of the long bow was not more copied by our neighbours. How severe this training was, may be gathered from certain statutes made long subsequently to the periods we have just spoken of, in the reign of Henry VIII., when portable fire-arms had been some time introduced, and when the practice of archery had in consequence somewhat declined. Henry VII., it should be premised, altogether prohibited the use of the cross-bow,* although he did not hesitate to use it himself for the purpose of shooting for wagers; this prohibition might have been effectual at the time, but it was not permanently so, as we may learn from the fact that Henry VIII., less than twenty years afterwards, renewed the prohibition. He forbade the use of cross-bows and hand guns, and passed a statute which inflicted a fine of £10 for keeping a cross-bow in the house.* Now followed a complaint from the bowyers, the fletchers (or arrow makers), the stringers, and the arrow-head makers, stating that many unlawful games were practised in the open fields, to the detriment of public morals and the great decay of archery. Those games were therefore strictly forbidden by Parliament; and then followed a third act, which obliged every man, being the king's subject, to exercise himself in shooting with the long bow, and also to keep a bow with arrows continually in his house. Fathers and guardians were also commanded to teach the male children the use of the long bow, and to have at all times bows provided for them, as soon as they arrived at the age of seven years. In connection with this compulsory shooting at marks, we must notice the following remarkable proviso:—"In case any person should be wounded or slain in these sports with an arrow shot by one or other of the archers, he that shot the arrow was not to be sued or molested, if he had, immediately before the discharge of the weapon, cried out 'Fast.'"† These statutes will show how necessary to the formation of an expert archer constant exercise in the use of these weapons was regarded.

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* Stat. 29 Hen. VII., A.D. 1508.

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* Stat. 25 Hen. VIII., cap. 17.

† Stow's Survey, by Strype, vol. i. p. 250.

Hereafter, where we treat of fire-arms, it will be found that in the reign of Henry VIII. they had arrived at no inconsiderable perfection, yet the long bow was still the favourite weapon. Indeed, much later, in the reign of Elizabeth, the musket was so unwieldy and slow to charge and discharge, that the bow was considered superior by many.* By this time, the prohibition of Henry VIII. against the use of the cross-bow had been forgotten, or was disregarded, for we find that in the year 1572, Queen Elizabeth, in a treaty with Charles IX. of France, engaged to furnish him with 6,000 men, part of them armed with long bows, and part with cross-bows; and in the attack made by the English on the Isle of Ré, in 1627, it is said some cross-bowmen were in the army, since which period they have been entirely laid aside, except for amusement.† The last time the legislature interfered for the protection of archery, was in 1633, when Charles I. issued a commission for preventing the fields near London being so inclosed "as to interrupt the necessary and profitable exercise of shooting." There have not been wanting, however, in later times, advocates for the occasional use of the long bow, in preference to the musket, and although the reasons adduced have some weight, they are greatly influenced by the prejudices of the writers. It is true that arrows can be shot from a long bow with far greater rapidity than balls from a musket, even with all the newest improvements: the flight of an arrow, too, is visible, but that of a ball is not; these two circumstances are in favour of archery. It has been maintained, also, that arrow wounds are more dangerous than those produced by ball, which to us appears, we must confess, a very doubtful proposition. It has been argued that, out of an equal number of arrows and balls, more of the former will hit the mark; a statement which is indeed probable, owing to the very unskilful manner in which the firing of musketry is usually conducted. An archer would be exposed to ridicule if he shot very wide of the mark; not so the musketeer, owing to the difficulty of discovering the fact. To this extent the advantages are on the side of archery; but let us now consider the disadvantages. In damp weather, the bow and bowstring were so much relaxed, that the efficacy of the instrument became very much impaired. A side wind deflected the arrow exceedingly in its flight, and against even a moderate wind it was difficult to shoot at all. In these respects the musket is as superior to the cross-bow as the latter is to the long bow. We need not, however, endeavour to settle this point on theoretical grounds, there being on record the particulars of a battle, in which muskets were opposed to bows, and the result was decidedly in favour of the former. We allude to the battle of Lepanto, fought between the Venetians and the Turks, in 1571, a detailed account of which is given by *Paruta,* the Venetian historian, who states that one chief reason why so few Christians were killed in comparison with the Turks, was because the latter used for the most part bows and arrows, whereas the former were supplied with muskets. True, the archers in this case were not English but Turks; these people, however, used the bow exceedingly well, perhaps just as well as our own ancestors.

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* Toxophilus; or, The Schole of Shooting.

† The long bow, however, continued in use until a later period: in 1643, a company of archers was raised for the service of Charles I., and the Marquis of Montrose employed archers against the Scots.—GROSE, *Mil. Antiq.*

Having thus far traced the history of the bow, we purpose giving a short account of its range and powers. Unquestionably, the longest arrow-shot concerning which we have any testimony, is that mentioned in Sir J. Malcolm's Sketches of Persia.* The story was originally told by Firdousi, the Homer of Persia, and has been repeated by many historians of good repute. In ancient times (so goes the tale), when Mensocheher the grandson of Feridoon, made peace with Afrasial, the Scythian invader, one of the articles of the treaty was that Persia should have all the country to the north-east, over which an arrow could be shot from Demavend. A hero named Arish ascended to the top of the mountain, and shot an arrow to the banks of the Oxus, a distance of between five and six hundred miles. One Persian author, in relating this fact, states that the arrow, which was discharged at sunrise, did not fall until noon! and another author of high reputation informs us that the festival of the arrow, on the 13th of October, which is still kept by the followers of Zoroaster, is in consequence of this event. Neither historian states from what kind of bow this was shot; the general tenor of the story would seem to indicate the *long bow*. The English archers, justly celebrated as they were for the long range and precision of their shots, could not accomplish more than 600 yards—at least, except on a few extraordinary occasions. The greatest range which our modern English archers can accomplish is from 300 to 500 yards. The Turkish ambassador, when in England in 1795, sent an arrow upwards of 480 yards, in the presence of several members of the Toxopholite Society.* His bow was made of horn, and is still in their possession. This was considered a very long shot; yet there are two or three on record, as occurring since archery has been merely a pastime, which have exceeded it by twenty or thirty yards.†

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* Vol. ii. p. 104.

With regard to extraordinary feats of correct aim, history affords us several instances. The story of Astor of Amphipolis and Philip is well known, but savours a good deal of the improbable. The reputed feats of Domitian in archery are more worthy our credence. He would frequently, it is said, cause one of his slaves to stand at a great distance, with his hand spread as a mark, and would shoot his arrows so correctly as to drive them between his fingers. Commodus, too, was a very expert archer, and with an arrow headed with a semicircular cutting edge, he could sever the neck of a bird. The story of William Tell is known to every one, and generally regarded in the light of an historical fact: this, however, does not seem likely to be the case, there being many reasons to suppose that his historian borrowed the tale from a Danish story related by Saxo-Grammaticus, who wrote in the twelfth century. This very feat he states to have been performed by *Toko*, a Dane.*

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* The Turkish Ambassador's secretary said that the (then) present Grand Sultan shoots 500 yards, which is the greatest performance of the modern Turks; but that pillars stand on a plain near Constantinople commemorating ancient distances, about 600 yards. (Mem. Mr. Jones at Mr. Waring's, an. 1796.) —*Banks. MS. Mus. Brit.*

† There is a tradition, that an attorney of Wigan, in Lancashire, shot a mile in three flights. By 33 Hen. VIII., no one aged twenty-four is to shoot at any mark under eleven score yards.

In illustration of our subject, we shall be pardoned for making a pretty long extract from Garrick's collection of old plays, where there are found two legends relative to the skill of English archers. The first is related in a ballad of eight fyttes or parts, entitled "A Merry Geste of Robin Hode." According to the story, the king (Edward IV.) disguised himself as an abbot, and paid Robin a visit. The outlaw, by way of entertainment, proposed a shooting match. He set up two wands, but so far removed from each other that the king made some objections: but we will quote the ballad:—

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* Tales and Popular Fictions, &c., by Thomas Keightley, 1834.

"By fifty space our kynge sayde
The markes were too longe.
On every syde a rose garlande
The shot under the lyne.
Whoso faileth of the rose garland, said Robyn,
His takyll he shall tyne,[*]
And yelde it to his maister
Be it never so fine.
Twyse Robyn shot about
And ever he cleved the wande."

Little John, Scathelocke, and Gilbert did the same; but

"At the last shot that Robyn shot
For all his frendes fore,
Yet he fayled of the garland
Three fyngers and more."

Of course he forfeited his "takyl," which he consequently presented to the disguised king.

The second ballad refers to Adam Bell, Clym of the Cloughe, and William Cloudesdale; archers as celebrated in the northern, as Robin Hood was in the midland counties. The king is represented in company with these worthies, and the royal archers having set up the marks, Cloudesdale censured them, saying,

"I hold him never as good archer
That shoteth at buttes so wide;"

and having procured two "hasell roddes," he set them up, at the distance of four hundred yards from each other; his first attempt at shooting at them, contrary to the king's expectations, was successful, for it is said,

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[*] *I. e.*, shall lose it.

> "Cloudsdale with a bearyng arrowe
> Clave the wand in two."

The king was naturally much surprised at this exercise of skill, and told him he was the best archer he had ever seen. The brigand on this said he would show him a still more extraordinary proof of his talent, and tying his eldest son, a child of seven years old, to a stake, and placing an apple on his head, he retired one hundred and twenty paces from the child's back, and having cautioned the spectators to be silent, and his son to stand still,

> "He then drewe out a faye brode arrowe,
> His bowe was greate and longe,
> He sette that arrowe in his bowe
> That was both styffe and stronge.
>
> "Then Cloudesdale cleft the apple in two,
> As many a man might se,
> Over Gods forbode!* sayde the king,
> That thou shode shote at me!"

These quotations are not made with the view of their being received as undoubted historical records, but popular traditions are nevertheless valuable in giving breadth and tone to undisputed facts of a similar nature. Had these tales been egregiously beyond the limits of probability, they could scarcely have succeeded as popular ballads intended for the age in which they were made. Indeed, history would seem rather to strengthen the probability of the skilful archery just mentioned. Carew, speaking of the skill of the Cornish archers* two centuries back, says, "For long shooting, their shaft was a cloth yard in length, and their prickes twenty-four score paces, equal to 480 yards, and for strength they would pierce any ordinary armour; and one Robert Arundell, whom I well knew, could shoot twelve score paces with his right hand, with his left, and from behind his head." Another anecdote of the skill of the Cornish archers is related in the Life of Henry VIII. by Hall. "There came to his grace (the king) a certayn man with a bowe and arrowe, and he desired his grace to take the muster of hym and to see him shoote; for that tyme his grace was contented; the man put hys one fote in his bosome and so dyd shoote, and shote a very good shote, and well towardes hys marke; whereof not onely his grace, but all others greatly merveyled; so the kynge gave him a rewarde, and for this curious feate he afterwards obtained the bye-name of Fote in Bosome."

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* God forbid!

The bow now having become a mere toy, it would be highly interesting to know the amount of force with which our renowned archers could formerly hit an object at a given distance. A journal of King Edward VI. partly supplies us with this information. His majesty relates that 100 archers of his guard shot before him two arrows, and afterwards altogether. The object aimed at was a well-seasoned deal board, an inch in thickness: many arrows pierced it quite through, and some stuck in another board on the other side. Unfortunately, the distance is not mentioned, but we know that Henry VIII. prohibited any one above the age of twenty-four years to shoot at a mark at a less distance than 220 yards,[*] and we may presume that professed archers, on such an occasion as a trial of skill in presence of their king, would shoot at a much longer distance than the legal minimum.

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* Survey of Cornwall, 1602.

It might be imagined that the cross-bow, bent as it was by the aid of machinery, would be capable of projecting an arrow further than the long bow; such, however, does not seem to have been the case. According to Sir John Smith,[†] a cross-bow will kill point blank between forty and sixty yards, and if elevated, six, seven, or eight score yards, and even farther. Mons. William de Bellay[‡] gives the cross-bow a still greater range, and says that if archers and cross-bowmen could carry about their provision for their bows and cross-bows as easily as harquebusiers do for their harquebus, he would prefer the former weapon over the latter. He states, moreover, that cross-bowmen and archers would kill at 100 or 200 paces, as surely as the best harquebusier. On the whole, it appears that the cross-bow was more certain of hitting a mark than the long bow, but could not be shot with such rapidity, nor would it throw so far. Cross-bows not only shot arrows, but also darts, called *quarrels* or *carreaux*, from their heads, which were square pyramids of iron. They also shot stones and bullets. There were two sorts of cross-bows used in the English service, one called latches, and the other prods. The Genoese were most expert in the use of this weapon.

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[*] 33 Henry VIII.

[†] Instructions and Observations, &c., p. 204.

[‡] Instructions for the Wars, 1569.

Both archers and cross-bowmen were subject to be greatly annoyed by the attack of cavalry. For the purpose of defending themselves under these circumstances, they were supplied with sharp stakes, which they planted in the ground, and presented to the advancing troops, after the plan of the modern bayonet. Very late, indeed, in the annals of archery, in the reign of Charles I., an individual called Neade developed an exercise of bow and pike together. The evolutions were witnessed by the king, in St. James's Park, were approved by him, and ordered to be taught throughout England; but political storms would appear to have prevented the execution of this mandate.* For the amusement of the curious, we append the words of command for this exercise:—

Order your pike.
Slope your pike.
Unfasten your bow.
Draw out your arrow.
Nock your arrow.
Shoot wholly together.
Port your pike and march.
Port your pike and retire.

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* The description of this exercise was printed in 1633, under the title of "The Double-armed Man."

Fasten your bow.
Recover your pike.
Advance your pike.
Come up to your close order.
Charge your pike.
Recover your pike.
Shoulder your pike and march.
Comport your pike and march.

Other testimony, indirect but authentic, may be adduced to show the great power of the long bow. We have before us a treatise on military surgery, by William Clowe, Surgeon to Queen Elizabeth.* In this book is related a case of injury from an arrow, which demonstrates the force with which the weapon was imbedded in the thigh bone, and the great difficulty experienced in extracting it. We shall make no apology for quoting this narrative, which is doubly interesting, showing as it does how a rude and empirical practice of surgery must have added to the danger of wounds in those days.

" *The cure of a servingman, which was shot into the leg with a sheafe arrow, and the head sticking in the bone.*

" A few yeares past, at a great mustering and training up of souldiers, at Pile End Greene, neere London: amongst those bands of trained men there was appointed a certain number of archers: who after they had marched a long time, in the end the bow-men were divided from the pike-men, and shot onely to trie and exercise their bowes: it chanced in their shooting at a marke, about sixe or seven score off, by misfortune one of their arrowes did hit a gentleman's seruant called Master Withipole into the outside of his left legge, so that the shaft was firmly fixed in the bone, *yet being a good way off beyond the marke when he received this hurt.*" The italics are ours, not the author's. Here, then, is an instance of an arrow being embedded in the leg bone (with what firmness we shall hereafter see), at a distance *a good way* beyond a hundred and forty yards. We will now resume the quotation. "There was at that time one in the field which professed surgerie, and proffered to dress the wounde, presently in the place where the patient was hurt: hee being in great paines, was glad of any helpe, and so permitted the fellow to dresse him, who forthwith did attempt to take out the arrowe, nothing regarding the renting or tearing of the muscles, but ouer-hastily, and unaduisedly did pull out the shaft, and left the arrowe-head fast fastened in the bone, being a barbed head, *as are commonly all our English sheafe arrowes.* After, willingly he would have excused the matter, and seemed to say, that the head was ill glued or fastened to the arrowe, and so he dressed the patient, to his friends' great disliking, for that the patient was immediately troubled, and molested with a hot distemperature, much pains, and innumerable swellings, which induced a feuer, and his stomacke clean taken from the meate. Then it was the will and pleasure of one Master Spinola, in Fenchurch Street, where I did dwell, to send for me, and there I found the surgeon, but his patient being in extreme paines: wherefore in my presence, for that they would be rid of this fellow, they said they were greatly aggrieved with him, and told him that he had stained his practice in preseruing and dressing the patient so ill, and that his abuse was great, and deserved punishment. Then he went about to blear their eyes with a little beggarly eloquence, the which he had learned amongst a sort of treacherous runagates, counterfeit land-lopers, sophisticall mountybanks, cosening quacksaluers, and such like false ingling deceiuers, with their paradoxical innovations, whose native soile is to them a wilde cat, and who abuse all good artes wheresoeuer they come or abide. But to auert circumstances, I say, he vanished awaye in darkness, as may appeare in my former bookes, where I have more at large spoken of him and other the like abusers, whose bloudy hands, without knowledge, doe hazard the lives of many." Mr. Clowes, having thus abused his rival pretty copiously, yields to the torrent of his emotions, and rejoicing in his superiority over the other practitioner, favours us with no less than four stanzas of poetry, in glorification of himself and depreciation of his rival. We shall take the liberty of omitting this effusion, and see what our surgeon does to extract the weapon. "I did put downe a probe," says he, "into the bottome of the wound, where manifestly I did feele the head fixed in the bone, and by reason the orifice of the wound was so straight and swolne, that I could not dilate any instrument sufficiently to apprehend and take hold of the arrowe-head, therefore I was driuen to make reasonable large incision down to the bottome, and then did put into the place of my incision a dilatorium, to open the wound, and so presently took hold of the arrowe-head with a *rostrum gruinum*, and then moved it by little and little, so very gently with safety I tooke out the arrowe-head." He then details the progress of the case to its result, which was favourable, and proves that, for those days, he was a very accomplished surgeon.

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* "A profitable and necessarie booke of observations for all those that are burned with the flame of gunpowder, &c., and also for curing of wounds made with musket, and caliver shot, and other weapons of warre commonly used at this day both by sea and land, as hereafter shall be declared. With an addition of most approved remedies, gathered for the good and comfort of many out of divers learned men, both old and new writers."—4to. 1637. *Black letter.*

We have given the foregoing description thus in detail, as throwing much light upon an interesting subject: among other things, it mentions a peculiarity of the English sheaf arrow. Antiquarians have made inquiries relative to the difference between *flight arrows* and *sheaf arrows*. The latter are known to have been the shorter and heavier of the two, adapted for the purposes of war; whereas the former were longer and lighter, employed for shooting at a mark. Clowes gives us a further amount of information: he tells us that the English sheaf arrow was usually forked.

The old writer Giraldus Cambrensis relates instances of the force with which an arrow may be shot, much more extraordinary than anything we have yet mentioned on the same subject. He says that some archers belonging to the Venta, a warlike tribe of Wales, shot at the oak doors of a portal, behind which certain soldiers had concealed themselves.[*] These doors were no less than four fingers in thickness, yet the arrows penetrated quite through. It is related also by William de Breusa, according to the same author, that, in a battle at which he was present, a Welshman having directed an arrow at a horse soldier, who was clad in armour, and had his leather coat underneath, the arrow pierced the man through the hip, penetrated the saddle, and mortally wounded the horse. Another Welsh soldier pinned a man through the hip to the saddle in a similar way, and with this addition, the man feeling the wound, pulled the bridle and turned about, when immediately he received a second shaft in the other hip, which fastened him to the saddle on that side also, in such a manner that he could not stir.[†]

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[*] Temp. Hen. II.

[†] *Itinerar. Cambriæ*, Gir. Camb., p. 805-20.

Those who wish for further information on the power of the bow, may refer to Froissart's Chronicles, Ascham's Toxophilus, the various treatises on war of Sir J. Smyth, Knt., Philip de Commie on archery (temp. Hen. VI.), Markham's Art of Archery, and The Banksian MS. on the same subject.

ANCIENT ARTILLERY.

THE term *artillery*, as formerly applied, had a very different signification from that which we now assign to it, the word being pretty nearly synonymous with *archery*. In the present instance, however, we do not intend employing it in that sense; we mean it to comprehend a list of those larger machines of projectile warfare which were used in place of the modern cannon.

No sooner did the spread of civilization cause men to assemble in communities, and prosecute the arts which are inseparable from such a condition, than increasing wealth began to incite the cupidity of the civilized races. Towns were now built, and surrounded with lofty walls, to attack which engines of great size and power were necessary. Great as is the increase of power conferred, by gunpowder, to the modern artilleryman, and wonderful as is the precision to which artillery practice is now brought, it must be confessed that a higher order of genius was necessary to the ancient engineer. To him the whole region of mechanical science was an open field on which he might exercise his constructive skill; levers, pulleys, and springs might be employed in thousands of varying arrangements, forming collectively engines of terrific force; whereas the modern engineer, so far as regards the formation and use of weapons, is restrained within very narrow limits; to employ, in short, the explosive force of gunpowder, either in a tube for the purpose of projecting a ball, in a tube which may be itself repelled, in a shell, or in a mine. So great is the force of gunpowder, and so constantly are our ideas associated with the fact of its being now solely employed to project large bodies, for the purpose of battering down walls, that on rising from the contemplation, we begin to wonder that any other agent could have been capable of similar effects. One circumstance usually escapes our notice,—that the momentum of a projectile, or the force with which it impinges upon an object, is equal to its weight multiplied by its velocity. True, the ancient engines of war could not project a mass with the same velocity as a cannon projects a ball; but then those masses were so much larger and heavier than any cannon-ball, that the comparatively small initial velocity was compensated for.

The structure of fortifications, and that of offensive engines, must mutually influence each other. In ancient times, before the invention of fire-arms, the strength of cities depended on the height of their walls; *now*, this would constitute a weakness; whilst, on the other hand, our modern, low, fortified walls, would have been no defence against the ancient mode of attack.

As we have already remarked, the forms of ancient engines of war were very many, differing according to the taste or constructive skill of the architect: they may, however, be included in the following classes:—

1. Catapultæ and balistæ, or engines formed on the principle of the cross-bow.

2. Instruments formed on the principle of the sling.

3. The battering ram.

4. Towers of war, from which projectile weapons were thrown.*

THE CATAPULT.—So easily is the common bow made a cross-bow, and so wide are the limits of size within which the cross-bow can be made, that the formation of gigantic engines of this kind was not a very elaborate suggestion to the mind of its first inventor. Thus originated the catapult and the balista, both engines of the cross-bow kind, but employed for different uses—one throwing darts, and the other stones.*

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* The chief engines of war of the ancient Greeks and Romans were the aries, catapult, balista, and onager, slightly altered in shape, occasionally, without doubt, in order to accommodate them to particular services. These machines remained in vogue until considerably after the discovery of gunpowder, yet designated by a great variety of names. When we consider that the historians of those periods were monks, totally unacquainted with the details of the art of war, and possessing but a crude knowledge of mechanics, we shall not wonder at this multiplication and confusion of names. The principal military engines of the eleventh and twelfth centuries were, exclusive of the balista, catapulta, onager, aries, and scorpion, the mangonel, trebuchet, petrary, robinet, mategriffon, bricolle, beugle or bible, espringale, matafunda, ribandequin, engine à verge, and war wolf.

The beugle, or bible, was an engine for throwing large stones, as we learn from an ancient poem:—

"Et pierres grans et les perrières
Et les bibles qui sont trop fières;
Gétent trop manuement."

(From the romance of *Claris*, in the French king's library, No. 7534.)

For a detailed account of these engines, see Grose's Military Antiquities, vol. i. p. 382.

Without diagrams to illustrate the subject, it would be of no great service to describe minutely such accounts of those instruments as have been handed down to us; suffice it to say, that, in making those enormous cross-bows, a very curious expedient was resorted to in order that an increase of elasticity might be gained. Instead of making the bow out of one piece of substance, it was formed in two parts, each of which was merely a straight arm. To form the machine, each piece, at its mesial extremity, was closely matted in amongst the fibres of a rope placed vertically, and firmly secured at either end. From this arrangement it is evident that the bow could not be bent without producing great tension of the ropes, thus adding another force to that of the resilient steel. A windlass, or capstan, was employed to bend these enormous bows, and when bent, the string was secured by a catch and iron pin. In order to discharge this machine, the pin was suddenly knocked out by the blow of a mallet.

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* The terms *catapult* and *balista* have been generally confused, by most who have written on the subject.—M. Folard, in his *Traité de l'Attaque et de la Defence des Places des Anciens*, considers that the catapult was the same as the *onager*, an instrument of the sling kind. In favour of this opinion he can show no evidence; while, on the other hand, there is authority directly opposed to his statement. *Heronis ctesibii Telefactiva* represents it as a cross-bow with two straight arms, the opposed ends of which were respectively embedded in the cords of a vertical rope: moreover, ancient writers constantly confounded the term *balista* with *catapult*, which is another argument in favour of their similarity. In our ancient law Latin, the term catapulta signified a sling.—GROSE's *Military Antiquities*.

Catapultæ have occasionally been employed in modern warfare. There was one erected at Gibraltar, at the desire of Lord Heathfield, by General Melville. It was for the purpose of throwing stones a little way over the edge of the rock, in a particular place where the Spaniards used to frequent, and where they could not be annoyed by shot or shells. Of all the machines which were formed on the principle of the sling, that called *onager* is the best known, and may be regarded as typical of the others. Its force entirely depended upon the torsion of a short thick rope acting upon a lever which described an arc of a vertical circle. Its construction may be very well illustrated by the common toy of a *jumping frog* or *mouse.* Most people have seen these little articles of amusement, and to such a description is unnecessary; for others, however, who have not seen them, the following description will be intelligible. The tail of the animal is a flat piece of wood imbedded in a short twisted rope, in such a manner that the end of the tail projects naturally in a horizontal position from the body of the animal. Under the body is a lump of wax, to which the tail, bent forcibly under, is attached, and the instrument placed flat upon the ground. Gradually the tail separates from the wax with a sudden spring, and the animal is projected upwards and forwards. The *onager* was a machine formed, then, on exactly similar principles; the lever had attached to its free extremity a sling; or sometimes it merely terminated in a spoon-shaped cavity; when bent back, it was secured by a catch or trigger, and charged with a stone. On starting the catch or trigger by a sudden blow with a mallet, the lever described its arc of a circle with great velocity, and projected the stone to a considerable distance.

THE BATTERING RAM.—Of all the ancient projectile weapons, none was so efficacious, or has retained its celebrity so long, as the battering ram. Strictly speaking, it was not a projectile weapon, in the modern and usual acceptation of the term; literally, however, it comes within the limits of that denomination, and under no circumstances can its description be omitted in a treatise having the objects of our own in view. The enormous size of this celebrated machine, the number of men used in working it, and the magnitude of the effects which it was capable of producing, might well awaken our incredulity, were they not attested by abundant evidence, and confirmed by modern experiment. The battering ram consisted of a long pole or spar headed with a huge mass of iron or brass, usually shaped like that portion of the animal which conferred upon it the distinctive name. This spar was sometimes mounted on wheels, but more frequently suspended by cords from a triangle of stout beams. In either case the object was to impel it violently forward against an opposing wall; not with a view of its penetrating the mass, or even of dislodging a portion by its immediate shock, but to set up a vibration that, continually repeated, shook the strongest walls to their foundation, and eventually made them fall.

Originally, the battering ram was probably nothing more than a long beam, which the soldiers carrying in their arms, urged by mere manual force against any obstacle that might oppose itself to them; the suspension of the beam from a triangle, or the mounting it upon wheels, was a self-evident suggestion, that required no great amount of constructive ingenuity to appropriate. Vitruvius affirms that the *aries*, or ram, in its simplest form, was first used by the Carthaginians when they laid siege to Cadiz; that Pephasmenos, a Tyrian, afterwards contrived to suspend it with ropes; and that finally, Polydas, the Thessalian, mounted it on wheels, at the siege of Byzantium under Philip of Macedon. Pliny, however, states that the ram was used at the siege of Troy; and thus the fable of the wooden horse was allegorical. Some have ascribed the invention to Artemorus, a Greek architect, who flourished 441 years before Christ. Others have imagined that the rams' horns mentioned by Joshua as causing the fall of the walls of Jericho, were merely figurative of this instrument.

The ram was usually of enormous dimensions. According to Plutarch, Marc Antony, in the Parthian war, used a ram of 80 feet long; and Vitruvius states that they were sometimes made 106 and sometimes

120 feet long. We may easily suppose that a great number of men must have been absolutely required to wield so enormous a machine; in fact, a whole century of soldiers was employed for this purpose, and when tired, they were relieved by others, so that the vibrations produced were continuous. Modern writers on artillery have made some interesting calculations relative to the comparative force between the battering ram and cannon-balls. Dr. Desaguliers* has shown that the momentum of a battering ram 28 inches in diameter, 180 feet long, with a head of cast iron of one and a half tons, the whole ram weighing with its iron hoops 41,112 pounds, and moved by the united strength of 1,000 men, would only be equal to that of a ball of 36 pounds weight shot point blank from a cannon. In this calculation, however, a very important element has been omitted, namely, the size of the impinging extremity of the battering ram, which, if its penetrating effect is to be compared with the penetrating effect of a 36 pound ball, should not be of greater size than the latter. Doubtless, however, it was of greater size, and therefore the momentum of the impinging extremity was diffused over a larger surface: thus the penetrating effect of the instrument would be considerably diminished, whilst its concussing, or vibratory and disintegrating effects would be increased. Now, against the tall walls of ancient fortifications, these latter qualities were far more destructive

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* Lectures, vol. i. p. 65.

than mere penetration. If a slate stone be fixed erect on an edge, and struck with a bullet urged by gunpowder, the chances are that the stone will be perforated, but not thrown down; if, however, the bullet be impelled against it by the hand, the stone will certainly not be perforated, but, on the other hand, will most likely fall. The two cases afford a very good illustration of the difference in effect between the modern cannon and the ancient aries: the former impels a projectile with great velocity against an object, and penetrates and shatters, without much disturbing, the repose of masses situated near its point of impingement; the latter possessed comparatively little penetrating force, but shook the strongest walls to their foundations. Many curious instances might be mentioned of the great effects produced by periodic vibrations; one of the most familiar, perhaps, is the well-known result of marching a company of soldiers over a suspension bridge, when the latter, responsive to the measured step, begins to rise and fall with excessive violence, and if the marching be still continued, most probably separates in two parts. More than one accident has occurred in this way, and has led to the order (we believe) that soldiers in passing these bridges, must not march, but simply walk, out of time.

Another curious effect of vibration in destroying the cohesion of bodies is the rupture of drinking glasses by certain musical sounds. It is well known that most glass vessels of capacity, when struck, resound with a beautifully clear musical note of invariable and definite pitch, which may be called the peculiar note of the vessel. Now, if a violin or other musical instrument be made to sound the same note, the vessel soon begins to respond, is thrown into vibrations, its note grows louder and louder, and eventually may break. In order to insure the success of this experiment, the glass should not be perfectly annealed; however, the *tendency* to break is invariably the same.

As the peculiar genius of modern artillery lies in perforating substances, one great quality of the battering ram has since the introduction of fire-arms been in great measure lost; engineers now, however, are beginning to see the advantages arising from the use of hollow shot, fired with diminished charges, by which means large masses are projected with diminished velocity, thus increasing their shattering, but diminishing their penetrating effects.

The battering ram, although sometimes used as we have described it, was more generally employed in connection with a vast tower called *testudo*, which we shall now proceed to describe.* It must be premised that the walls of ancient cities were of an amazing altitude, and therefore warriors placed on them encountered their opponents at a great advantage. Against such defences as these, soldiers armed with manual weapons availed but little, except by some means they could gain an elevation which commanded the city walls. This object was accomplished by employing towers of enormous magnitude.* Hero distinguishes three kinds of them; the smallest were, he says, sixty cubits, and five storeys high; the base, which was square, measured on each side sixteen cubits. The larger towers were ninety cubits high, and consisted of fifteen storeys; the greatest, called *double*, were of twenty stages, were largest at bottom, and decreased every storey. These towers were supported on wheels of enormous size and strength; six was the number for the smaller towers, and eight for the larger ones. The lower storey was devoted to the battering ram, all the others were filled with archers, and light-armed soldiers generally. These large towers being brought up close to the fortifications, and overlooking them, became very dangerous machines, and consequently many expedients were devised for their destruction. Large excavations were made under the tract along which the machine must pass, in such a manner that its vast weight, not being supported by the superficial crust, made it sink into the snare. Arrows furnished with combustible materials were shot against it from bows and military engines, to guard against which the machine was usually covered with raw hides or metal scales, and hence the name of testudo, which eventually the whole engine acquired. If, despite these precautions, it nevertheless succeeded in arriving close up to the city walls, vast stones were thrown upon it;

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* The terms Vinea, Pluteus, and Helepolis were also applied to these towers.

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* Sometimes, too, by expedients of greater ingenuity. Belisarius conquered Palermo by sailing into the harbours, elevating his boats to the mast-head, and from thence assailing the garrison.

—boiling water, melted lead, hot sand, and in short, every material of annoyance which circumstances or ingenuity enabled to be used, was thrown upon the hapless warriors. Nooses of rope or chain were let down from the walls, and in these the head of the battering ram was entangled. Bags of wool, hurdles of wicker-work, and other soft and yielding materials were lowered, for the purpose of encountering the blows of the ram, and diminishing their violence. Not unfrequently these measures succeeded, for, unquestionably, in this primitive development of the art of siege, the assailed were more favourably circumstanced than the assailants. If, however, the testudo still maintained its ground unscathed, its occupants next threw out a drawbridge* across the chasm, and rushed across it to the fortification.

Such is a description of the towers used by the ancient Greeks and Romans, as related by Vitruvius, Ammianus, Marcellinus, and other writers on these subjects. The towers or belfries of more modern times were never so large, rarely exceeding two or three stages in height. These machines underwent very little, if any, alteration in form down to the period of the discovery of gunpowder. In the dark ages, however, we find them mystified by a great variety of fanciful names, amongst which we may enumerate the *sow*, a term frequently applied, in later periods, to those moveable towers. This name is said by some to have been derived from the circumstance of the contained soldiers lying closely together, like pigs under a *sow*, and hence the witty, but not very delicate remark, of a certain Countess who defended the castle of Dunbar against King Edward III., in threatening, that unless the Englishmen kept their sow better she would make her cast her pigs. This circumstance is mentioned by Camden, who also says, "the sow is still used in Ireland." During the siege of Corfe Castle, by the Parliamentarians, they used two machines of the above kind, one named the boar, and the other the sow.

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* Called *Exostra.*—VEGETIUS, *De Re Militari.*

With regard to the power of ancient artillery, it is probable that we cannot have in the present day any very correct notions. Judging, however, from the materials used, and the mode of their application, it must have been very great, although not comparable with that of missiles urged by gunpowder. Athenæus speaks of a catapulta which was only one foot long, and threw an arrow to the distance of half a mile. Other engines, it is said, could throw javelins from one side of the Danube to the other. Balistas threw great beams of wood, lances of twelve cubits long, and stones that weighed 360 lbs. Polybius mentions that balistas were used to throw stones against vessels entering into port. Josephus, too, has related several instances of the power of ancient artillery: he tells us they beat down battlements and corners of towers, and overthrew whole files of soldiers, even to the rear rank. He says that one of Vespasian's rams, which was only ninety feet long, and which was smaller than many Grecian rams, had a head as thick as ten men, and twenty-five horns, each of which was as thick as one man. Its weight was 1,500 talents. (171,000 lbs. troy.) When removed entire, 150 yoke of oxen, or 300 pairs of horses and mules, were required to draw it, and the united strength of 1,500 men was employed in forcing it against the walls. Such are the accounts of effects produced by missile engines employed by the Greeks and Romans; and scarcely less terrible are those related of the same engines or their derivatives, when used in more modern times, although the mechanical skill of the ancients was then in great measure lost. It would seem, however, that our ancestors, in describing the military engines of the dark ages, must have greatly exaggerated their effective range and powers; otherwise many of our ancient castles would not have been built in situations where they could be commanded by hills at a distance of four or five hundred yards from them, instances of which may be seen in the castle of Dover, once deemed the key of this kingdom, also of Corfe and Guildford. Monsieur Joly de Mezeray says, that the greatest range of a mangonel was five stadia, or 1,042 yards. These machines not only threw large darts and stones, but also the bodies of men and horses, as is mentioned more than once by Froissart.

Our account of ancient weapons being merely preliminary to an investigation of the properties and effects of gunpowder, as well as other explosive substances, we shall not go into further details concerning them, but will presently enter upon the other branches of our subject. Interesting as it may be to raise up before our imagination engines of bygone times,—the ponderous ram, battering against the lofty walls of an ancient city; the catapult and balista, hurling their darts and massy fragments; barbed arrows glancing from coats of mail, and encounters of gallant knights and squires bold; we cannot forget that fiction every now and then weaves her misty web around those records of former deeds where truth should reign supreme. Gladly, then, we hasten from such dim and dusky periods to those of later date, when other sciences besides mechanics lent their aid to the perfection of the warlike art. The reader will already have anticipated that our allusion refers to gunpowder, the most potent aid which chemistry or any other science ever proffered to the grim deity of war.

Between the balista and catapult, and other mechanical agents of war, and gunpowder, there is, however, a connecting link, namely,

THE GREEK FIRE,

Concerning which such marvellous accounts have been promulgated. Indefinite and variable as were the terms applied to chemical substances, until comparatively recent periods, it is not wonderful that we have received no credible testimony as to the composition of this celebrated Greek fire; nor, indeed, as to the period of its original discovery. It is pretended by some, that its composition was known to the Greeks of antiquity, but that we had no precise accounts concerning its use until the period of the Eastern empire. This assertion is, however, very improbable, and seems invented by one of those zealous enthusiasts who assert that, not only were the ancients pre-eminently felicitous in their sculpture, poetry, and indeed the fine arts in general, but also that they excelled in all branches of scientific acquirements; that the blaze of intellect in those days irradiated the whole domain of human learning, beyond the limits of which reason could not penetrate; in short, that the apparently brilliant results of the inductive process are a fallacy; that they are merely so many gems known to the ancients—buried amidst the intellectual ruins of the middle ages, and now restored again. It is certain enough, that we have no precise mention of the Greek fire in any ancient Greek or Latin author.* Gibbon appears to entertain no doubt of its invention by the Greeks of Constantinople, and of its having been subsequently stolen from them by the Saracens. According to Beckmann,† it was invented in the year 678 of the Christian era, by Callinicus, an architect of Heliopolis (the city afterwards called Baalbec), in the reign of the emperor Constantine Pogonatus, and its use was not discontinued in the East until the latter end of the thirteenth century. Procopius, in his history of the Goths, calls it Medea's oil, considering it as an infernal composition prepared by that sorceress. The writer of the "Esprit des Croissades" asserts that it was known in China in the A.D. 917, three hundred years after Constantine Pogonatus, that it was called *the oil of cruel fire*, and that it was carried there by the Kitan Tartars, who, in their turn, had it from the King of Ou. It is far from improbable that many Eastern nations used a liquid composition of this kind in their wars, and that it was discovered by several parties having no communication with each other. We know that in Persia, also in the Island of Zante, and many other parts of the world, there are naphtha springs, which continually pour out this inflammable liquid; we also know that the Parsees, or fire-worshippers, employed naphtha in supporting their religious flames. All they found necessary to do for this purpose was to insert one end of a cane a little way under the earth so impregnated with naphtha, which ascended by capillary attraction, and was easily ignited. Now, it is well known that large districts are furnished with these naphtha springs, and a substance of properties so obvious could hardly escape being applied to the uses of war. Probably, then, naphtha was the basis of the Greek fire. We can hardly expect, at this time, to discover any trustworthy account of the operation of this compound, although many statements, such as they are, have been handed down to us. Nothing conduces so much to originate historic inaccuracy as fear, under the influence of which have been perpetuated the most inaccurate exaggerations. Terrible were the reputed effects of ancient cannon, and yet they were altogether incomparable to those of modern days; and the citizen of Leyden, who first received an insignificant shock from an electric jar, protested that he would not be subjected to such another for all the kingdoms of the earth!—yet the employment of fire-arms was coeval with the re-illumination of the moral horizon; and the discovery of the electric jar took place when the genius of inductive philosophy was rapidly pursuing her victorious career: we need not wonder, then, that accounts of the Greek fire, handed down to us as they have been by ignorant and credulous scribes, and from periods of much greater mental darkness than those to which we have alluded, should be unworthy of implicit credence. It is more than probable that different pyrotechnic contrivances have been unwittingly confounded with the celebrated Greek fire. Joinville favours us with a description which would seem to refer not so much to a burning liquid as to a *rocket*, which we know has been used as an instrument of war in India and China from time immemorial.* Joinville says, "It was thrown from the bottom of a machine called a petrary, and that it came forward as large as a barrel of verjuice, with a tail of fire issuing from it as big as a great sword, making a noise in its passage like thunder, and seeming like a dragon flying through the air; and from the great quantity of fire it threw out, giving such a light that one might see in the camp as if it had been day." Such was the terror it occasioned among the commanders of King Louis's army, that Gautier de Cariel, an experienced and valiant knight, gave it as his advice, that as often as it was thrown, they should all prostrate themselves on their elbows and knees, and beseech the Lord to deliver them from that danger against which he alone could protect them. This counsel was adopted and practised; besides which, the king, being in bed in his tent, as often as he was informed that the Greek fire was thrown, raised himself in his bed, and, with uplifted hands, thus besought the Lord: "Good Lord God, preserve my people!" Geoffry de Vinesauf, who accompanied King Richard I. to Palestine, says, that "with pernicious stench and livid flame it consumes even flint and iron, nor could it be extinguished with water."* The following Latin rhymes, composed by a Florentine monk, show the opinion which was in his time held of its properties:—

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* Something like it is alluded to by Quintus Curtius.

† *Beiträge zur Geschichte der Erfindungen.*

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* It is a common idea that Sir William Congreve was the first to introduce rockets as warlike instruments. Such, however, is not the case; he himself claims no such priority of invention, but candidly states, in his treatise on the military use of rockets, that he was aware of their having been employed from time immemorial in India and China. There formerly were several Chinese war rockets to be seen at the Adelaide Gallery of Practical Science. They were taken at Amoy. In point of size, they are much smaller than any used in our service; their case is made of paper, and they carry a barbed dart. Their

"Pereat ô utinam ignis hujus vena
Non enim extinguitur aquâ sed arenâ

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stick, as might be expected, is lateral and not central, as the modern Congreve rocket.

* *L'Esprit des Croissades.*

Vixque vinum acidum arctat ejus pœna
Et urinâ stringitur ejus vix habena:
Ignis hic conficitur tantum per paganos
Ignis hic exterminat tantum Christianos
Incantatus namque est per illos prophanos
Ab hoc perpetuo Christe, libera nos!"

The Greek fire was more extensively employed in European warfare than some have imagined. Pere Daniel relates that Philip Augustus, King of France, having found a quantity of it ready prepared at Acre, brought it with him to France, and used it at the siege of Dieppe, for burning the English vessels in that harbour. It was also, according to this author, employed in many other sieges in France. He also states, that a Frenchman named Gaubert, a native of Mante, discovered the plan of making it. Another Frenchman, named Dupré, is also said to have discovered its composition. And on the authority of Grose,* an Englishman was fortunate enough to unravel the secret, and that the king being unwilling to have it made known, conferred on him a pension to suppress it. According to the testimony of an Icelandic MS. entitled *Speculum Regale*, and supposed to have been written in the thirteenth century, the Greek fire, or something resembling it, was then commonly employed in Europe. The writer says, *Omnium autem quæ enumeravimus armorum et machinarum præstantissimus est in curvus clypeorum gigas flammas venenatas eructans.*

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* Mil. Antiq., vol. i. p. 380.

The Greek fire was employed in Europe long subsequently to the discovery of cannons, particularly in sieges. In 1383, when the Bishop of Norwich besieged Ypres, the garrison is said to have defended itself so well, and particularly with Greek fire, and *certain engines called guns*, that the English were obliged to raise the siege with such precipitation that they left behind them their great guns, which were of inestimable value. Afterwards the remainder of that army was besieged in the town of Barburgh by the French, who threw such quantities of Greek fire into it, that a third part was burnt, and the English were obliged to capitulate.*

So terrible are the reputed effects of this celebrated compound, that a knowledge of its true composition would be of exceeding interest. Several recipes have, indeed, been preserved to our own days, but they differ remarkably, and are all of them more or less inconsistent with the reputed effects of the substances. We must remember, however, that those effects were on the one hand doubtless exaggerated, and that the names of chemical substances employed were naturally ambiguous, and perhaps studiously made so.† The oldest prescription relative to the composition of the Greek fire, and the one seemingly most worthy of credence, is that mentioned by the Princess Anna Comnena, in which the component parts are said to be resin, sulphur, and oil. It has not, however, been found possible to produce a substance out of these ingredients at all like the reputed Greek fire: theory, indeed, would indicate that saltpetre ought to be one ingredient; this, however, is not mentioned. Nevertheless, we have abundant testimony, as we have proved, that it was a fluid, and that its knowledge was not confined to the Greeks. Moreover, during the Crusades, the Saracens frequently employed it with success against the Christians, as we have already mentioned,* and the armies of Genghis Khan† seem to have been furnished with it. One chief purpose for which this extraordinary fire was employed, was to annoy the enemy in naval engagements; it was then thrown from large engines, or sometimes, it would seem, blown through tubes. Fire-ships also were filled with it, and sent loose amongst a hostile fleet, and vessels containing it were shot from balistæ. Genghis Khan is said to have had in his army elephants furnished with these fire-tubes. It is a common opinion that in losing the composition of the Greek fire, we have lost an aid to war of far greater potency than gunpowder itself. This, however, is a mistake; the very fact of the Greek fire being a liquid would render it inapplicable to the purposes of modern warfare. If a liquid possessing the reputed qualities of Greek fire were desired, chemists would soon elaborate it in greater perfection than the Greeks of the Eastern empire, or Genghis Khan, or any other semi-civilized people. It is not consonant with the genius of modern warfare, and therefore has fallen into disuse. Bonaparte is reputed to have known the composition of the Greek fire, or at least a fluid closely resembling it, but considered it inapplicable. His opinion must be decisive of the question: all know how ardently he promoted the advancement of science; how he cherished the now obsolete sentiment that a sovereign's personal encouragement of science might be conducive to the public weal; how he attached to his court and loaded with honours the celebrated chemist Berthollet. Doubtless, under circumstances so favourable, had Napoleon wished to possess an inflammable liquid similar to the Greeks, his chemists could have supplied him. We repeat, then, that under these circumstances, if this compound had been adapted to the purposes of war as the art now exists, it would have been reintroduced.

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* J. Walsingham, pp. 303-4.

† As an instance of the ambiguity of ancient chemical terms, and of certain modern ones, we may remark, that Pliny frequently mentions *alum;* but there is very little doubt that our alum was not then known, and that he refers to rock salt. Again: the modern popular term *copperas* does not refer to a preparation of copper, as might be imagined, but to a compound of iron,—such are the fallacies of terms.

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* *L'Esprit des Croissades*, &c., Amsterdam, 1780.

† Patio de la Croix, *Histoire de Genghis Khan*.

GUNPOWDER.

We now come to the subject of gunpowder, — an invention which not only materially affected the art of war, but exercised most important influences on the fate of empires and the progress of civilization. As might readily be imagined, the honour of a discovery so important, has been claimed for more than one individual. Polydore Virgil and Thevet attribute the invention to a monk named Constantine Anelzen, who was a chemist of some celebrity in his time. Others maintain that it was discovered by Bartholdus Schwartz, about the year 1320. It is not difficult, however, to refer the invention to a period long anterior to the time of Schwartz, our own illustrious countryman, Roger Bacon, having distinctly mentioned it in the year 1267.* He describes its composition, enumerates some of its properties, and recommends its explosive powers as a means of destroying armies. He describes it as making a sound like thunder, and a flash similar to lightning, but exceeding the sound and brightness of natural thunder and lightning. He says it might be applied to the destruction of armies, and speculates on the probability of its employment by

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* His works were published in 1845, at Oxford.

Gideon, when he defeated the Midianites with three hundred men.* Bacon is usually said, by Englishmen, to have been the *inventor* of gunpowder, but a slight examination of the treatise alluded to will convince any unprejudiced person that he, far from laying claim to the invention, mentions gunpowder as a substance well known in his time, and employed for the purpose of pyrotechnical display. The passage alluded to is as follows: *Ex hoc ludicro puerili quod fit in multis mundi partibus scilicet ut instrumento facto ad quantitatem pollicis humani ex hoc violentiâ salis qui salpetræ vocatur tam horribilis sonus nascitur* (this is the description of a parchment cracker) *in ruptura tam modicæ pergamenæ quod fortis tonitru rugitum et coruscationem maximam sui luminis jubar excedit.*†

We can easily, then, shift the claim from Bacon to an anterior date, and Dutens‡ imagines he must have derived his knowledge from Marcus Græcus,|| who not only mentioned the ingredients of gunpowder, but gave better proportions of their substances than many of later date. In the Latin quotation which we have just made

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* Judges vii.

† See preface to Jebb's edition of Bacon's *Opus Majus.*

‡ Inquiry into the Origin of Discoveries attributed to the Moderns, by the Rev. Mr. Dutens.

|| The MS. of Marcus Græcus, which has given rise to this supposition, is still in the Royal Library at Paris. Both Dr. Mead and Dr. Hutton had a copy of it: Dr. Jebb also mentions it in his preface to Bacon's *Opus Majus.* The MS. is entitled *Liber Ignium.* Marcus Græcus lived about the end of the eighth century.

from one of Bacon's treatises, saltpetre alone is mentioned as being the horribly explosive substance; but saltpetre alone will not even burn, much less explode; a fact which, the presumption is, Bacon must have known. The question, however, does not rest on presumptions; Bacon himself, in his treatise *De secretis operibus Artis et Naturæ et de nullitate magiæ*, says that from "saltpetre *and other* ingredientes we are able to make a fire that shall burn at any distance we please." In another part of the treatise he gives us a little more information; the words are these: *Sed tamen salis petræ*, LURA NOPE CUM UBRE *et sulphuris, et sic facies tonitrum et coruscationem, si scias artificium.* Here two ingredients, saltpetre and sulphur, are plainly enough indicated; but what can be the ingredient called *lura nope cum ubre?* This obscure fragment of Latinity might puzzle the ghost of a Scaliger; nevertheless, some admirer of the great Friar has succeeded in proving that the barbarous words are merely a transposition of the letters *carbonum pulvere!* Those who are accustomed to admire the liberality of sentiment possessed by cultivators of modern science, and are unacquainted with the more circumscribed views and oblique sentiments of such as cultivated science in the ages of alchemy, will marvel at the pains which Bacon was at to preserve the secret; especially when it need not have been alluded to at all. Bacon, however, in following this course, merely subscribed to the doctrines of his age. Volume upon volume, for instance, has been written on the art of making gold and silver; every operator represents himself successful, but unfortunately the steps of his process are totally unintelligible. However, let us do the alchemists justice. They must needs write books, or their characters would have suffered: these books were intended to pass for oracles of wisdom, but the writers unfortunately had nothing to teach; they therefore employed a jargon of impenetrable mystery—perhaps the best substitute for wisdom in their age or ours.

If Bacon, then, did not discover gunpowder, to whom shall we refer it? Numerous documents can be adduced to prove that gunpowder was known in the East at periods of very great antiquity, and it might have been introduced into Europe, either through the medium of the Greeks of Constantinople, or the Saracens of Spain. Citizen Langles, in a memoir read before the French National Institute, contends that gunpowder was conveyed to us by the Arabs, on the return of the crusaders, and that the former people employed it at the siege of Mecca, in 690. He says they derived it from the Indians.* At the period when Roger Bacon lived, Spain was the favourite seat of literature and art. Unlike their rude and turbulent predecessors, whose sole object was the extension of Mohammedanism by the sword, the Spanish Saracens of those days were a polite and contemplative race, their seminaries and universities were the most celebrated in the world, and Christian Europe was glad to profit by the unbeliever's tolerance, and glean in Spain those fruits of learning which in other European countries found but a barren soil.* Bacon is known to have travelled through Spain, and to have been well conversant with Arabian literature: the account of the composition of gunpowder he might have seen in an Arabian manuscript; this is at least as probable a supposition as that he saw the treatise of Marcus Græcus; indeed, there is in the Escurial Collection a treatise on gunpowder written in 1249.

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* Wilkinson on Engines of War, p. 143.

The earliest account which we have of gunpowder exists in a code of Gentoo laws, where it is mentioned as applied to fire-arms, and consequently, if the document be authentic, the most recondite of its properties, that of projecting weights, must have been well understood.

That particular code in which gunpowder and fire-arms are mentioned, is thought by many to have been coeval with the time of Moses! The notice occurs in the Sanscrit preface, translated at page 53, by Halhed. It is as follows: "The magistrate shall not make war with any deceitful machine, or with poisoned weapons, or with cannon and guns, or any kind of fire-arms; nor shall he slay in war a person born an eunuch, nor any person who putting his arms together supplicates for quarter, nor any person who has no means of escape." Referring to this document, Halhed observes, "It will no doubt strike the reader with wonder to find a prohibition of fire-arms in records of such unfathomable antiquity, and he will probably hence renew the suspicion, which has long been deemed absurd, that Alexander the Great did absolutely meet with some weapons of this kind in India, as a passage in Quintus Curtius seems to ascertain. Gunpowder has been known in China as well as in Hindostan far beyond all periods of investigation. The word fire-arms is literally Sanscrit, Agnee-aster (agnyastra), a weapon of fire; they describe the first species of it to have been a kind of dart or arrow tipped with fire, and discharged upon the enemy from a bamboo. Among several extraordinary properties of this weapon, one was, that after it had taken its flight, it divided into several separate streams of flame, each of which took effect, and which, when once kindled, could not be extinguished;* but this kind of Agnee-aster is now lost. Cannon in the Sanscrit idiom is called Shĕt-aghnee (sataghni), or the weapon that kills a hundred men at once, from shĕtĕ (sata), a hundred, and ghĕnĕh (hana), to kill; and the Pooran Shasters, or histories, ascribe the invention of these destructive engines to Bĕĕshōōkermā (Viswakerma) the artist, who is related to have forged all the weapons for the war which was maintained in the Suttee Jogue between Dewta and Ossoor (Devata and Asura), or the good and evil spirits, for the space of one hundred years."†

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* *Vide* Thomson's History of Chemistry.

Dutens, in the work referred to, in page 344, has selected many passages from Greek and Latin authors, favourable to the opinion that gunpowder was known to the ancients. He mentions the attempt of Salmoneus to imitate thunder,* of the Brahmins to do the same thing;† but his most remarkable quotation is from the life of Apollonius Tyanæus, written by Philostratus; showing that Alexander was prevented extending his conquests in India, because of the use of gunpowder, by a people called Oxydracæ.

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* This description corresponds better with the nature of Greek fire than with that of gunpowder.

† Halhed, Transl. Gentoo Laws, introduction, p. lii.

The passage to which we have alluded is so curious, that we make no apology for giving it. "These truly wise men (the Oxydracæ) dwell between the rivers Hyphasis and Ganges; their country Alexander never entered, deterred not by fear of the inhabitants, but, as I suppose, by religious motives, for had he passed the Hyphasis, he might, doubtless, have made himself master of all the country round them; but their cities he never could have taken, though he had led a thousand as brave as Achilles, or three thousand such as Ajax, to the assault; for they come not out to the field to fight those who attack them, but these holy men, beloved by the gods, overthrew their enemies with tempests and thunderbolts shot from their walls. It is said that the Egyptian Hercules and Bacchus, when they overran India, invaded this people also, and having prepared warlike engines, attempted to conquer them; they in the meantime made no show of resistance, appearing perfectly quiet and secure, but upon the enemy's near approach they were repulsed with storms of lightning and thunderbolts hurled upon them from above."*

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* Virg., *Æneid*, vi. 585; Themistius' *Orat.* xxvii. p. 337. Dutens also quotes, in support of this argument, Hyginus, *Fabul.* 61, 650; Eustathius, *Ad Odyss.*, Α. 234, p. 1682, l. 1.

† Valerius Flaccus, lib. i. 662; Dion. Cassius, *Hist. Rom. in Caligul.*, p. 662; and Johannes Antiochinus, *Chronica apud Peirasciana Valesii*, Paris, 1604, p. 804.

It is true Philostratus is not considered remarkable for veracity,† and this assertion is not of a kind to be received without suspicion; but taking into consideration the records of oriental history, the fact of pyrotechny having been cultivated from time immemorial in India and China, his assertion does not seem to us at all improbable. In India and many other parts of Asia, nitre occurs in great quantity spread over the surface of the earth. Now, suppose a fire lighted in such a spot, the most careless observer must have noticed the effect of the saltpetre in augmenting the flame; if, then, attention having been directed to this phenomenon, charcoal and saltpetre had been mixed together purposely, gunpowder would have been formed. The third ingredient, sulphur, is not absolutely necessary; indeed, very good gunpowder, *chemically speaking*, can be made without it. Sulphur, however, increases the plasticity of the mass, and better enables it to be made into, and to retain the form of, grains.

Some persons refer us to Plutarch's Life of Marcellus, and Vitruvius, as authorities in favour of the supposition that gunpowder was known to the famous Archimedes. All are acquainted with the talented aid which he lent to Hiero of Syracuse in repelling the attacks of Marcellus—how by volleys of enormous stone he destroyed, at a considerable distance from the walls, a stupendous machine of war, floating on eight galleys, and termed the Sambuca; how he burned his opponents' ships by mirrors, hooked up their prows by cranes, and sank them stern foremost under the waves: in short, how he so terrified the enemy, that on seeing a rope or spar project from the wall, they cried out that Archimedes was levelling some machine at them. Amongst the engines which his fertile genius enabled him to construct, were some which are said to have gone off with a great noise—a description which it has been assumed does not apply to any then commonly in use, and that gunpowder seems indicated. To us this assumption does not appear to have much validity; we feel no difficulty in imagining the enormous engines used by Archimedes to have made *a great deal* of noise, even though their agency merely depended on bent springs and levers.

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* Lib. ii. c. 14.

† *Vide* Lemprière's *Class. Dict.*, art. Philostratus.

Those persons who are in favour of the opinion that gunpowder is a modern discovery, say that the historical records in which gunpowder is mentioned without ambiguity, such as the Gentoo codes, are of doubtful authenticity; that the narrative of Philostratus, besides its ambiguity of allusion, is vitiated by the character of the writer; that the traditions of other historians are obnoxious to one or both of the same remarks; that poetic allusions are not to be literally translated, and used as testimony in historic and scientific matters; and lastly, they urge that if gunpowder and fire-arms had been known so early in the East, some of the conquering hordes who roamed from thence and devastated Europe, should have used such powerful auxiliaries to war: at least, Mahomet should have been aware of this element of destruction, they say,* and still more so Genghis Khan; yet such was not the case.

These arguments have great weight, but are not insuperable. We may answer, that the discovery of gunpowder, and the discovery of fire-arms, are separate questions; that gunpowder might easily have been made by a savage people; that, indeed, in countries where saltpetre occurs naturally, it must have in a manner been formed by chance, whereas the manufacture of fire-arms involves a great amount of mechanical skill; hence missives urged by mechanical aid would long be thought superior to the first rude fire-arms, as in the present day the bow is preferred by the Chinese to the musket,—as it was in England in the reign of Henry VIII., and amongst the Turks not 200 years ago.

Thus, then, the dispute stands. We do not know who discovered this compound; certainly not the German Schwartz, nor the English Bacon, nor Marcus Græcus: we incline to the opinion that it has been known in Asia from time immemorial, and that its discovery might have originated in accident. Certain it is, however, that its first application to artillery in Europe was about the beginning of the fourteenth century.

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* Some believe Mahomet *was* aware of it. See page 59.

Having given a short sketch of the history of gunpowder, we might at once proceed to its application to fire-arms, and other warlike purposes. It seems more natural, however, to describe briefly the chemical nature of this substance, and the history and properties of the ingredients from which it is formed. It may here be as well to remind the reader that gunpowder is not a chemical, but a mechanical compound, and that it is composed of saltpetre or nitre, sulphur, and charcoal, intimately commingled and subsequently formed into grains.

It is not our intention to enter minutely into the chemical properties of these substances, but we may remark that their union forms an explosive compound which when inflamed eliminates a large quantity of various gases. Nitre, or saltpetre,[*] is a chemical compound of nitric acid and potash.[†] It may be made by directly uniting these two substances, but we need scarcely remark that such is never done, except as a matter of synthetical demonstration. In some parts of the world—in India, for example—it is found as a natural efflorescence on the earth's surface;*

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[*] The term *neter*, translated *nitre*, is found in the Old Testament, Prov. xxv. 20; Jeremiah ii. 22. Herodotus and Theophrastus used the word *νιτρον*, and Pliny the word *nitrum*—but these authors seem to mean *natron*, quite a different substance from our nitre. Geber (Invention of Verity, xxiii.) is the first who distinctly mentions our nitre or saltpetre. The term *saltpetre* is evidently derived from *sal-petræ*, literally signifying rock salt.

[†] Until very recent times the composition and theory of the

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efficacy of nitre in gunpowder was not understood. Machiavelli (in 1588) seems to veil his ignorance of the matter under a great many quaint suppositions. "Saltpetre," says his translator, Peter Whithorne, "is a mixture of many substances, gotten out with fire and water of dry and dustie ground, or of the flower that groweth out of new walles in sellars, or of that ground which is found lose within toombes or desolate caues, where raine can not come in; in the which ground (according to my iudgement) the same is ingendered of an ayrie moistnesse drunke up, and gotten of the earthie drines; whose nature (by the effect thereof) considering, I cannot tell how to bee resolved to say what thing properly it is. The well learned, and most wise physitions (besides medicinal experience), by the tast (finding it salte, and with exceeding sottill sharpnesse, and considering the great byting thereof), suppose verily that it is of a nature hotte and drie: on the other part, seeing it to be a thing engendered of ayre, and touched of fire to fall in a flame and vapore, and rise with a terrible violence, seemeth to be of an ayrie nature, hotte and moist: and againe, seeing it with shining and glistening whitenesse, as a thing to the nature of water conformable, it seemeth that it may be said, that it is of a watery nature."—P. 23.

* It also occurs pretty frequently as a natural efflorescence on the earth in many parts of Spain, especially in the south of Andalusia, where the peasants are in the habit of collecting it, separating foreign bodies by solution and evaporation, and finally manufacturing it by a domestic process into gunpowder. In Spain, the public gunpowder manufacture is a government monopoly, and the article is both dear and bad. Hence the peasants have long been stimulated into the preparation of their own. The operation is carried on with great secrecy, just as illicit distillation in the wilds of Ireland and Scotland, and subject to frequent interruption; yet the result is by no means despicable, as I have often proved. The chief defect of this

and this, indeed, is the only source from which we derive it. Other nations, however, not having the commercial facilities of England, make it artificially, by a process which was first perfected by the celebrated chemist Berthollet. The origin of the extensive manufacture of nitre is curious, and forcibly illustrates the advantage which may accrue to a state from its cultivation of science. At one period of the French revolutionary wars, operations had nearly ceased, owing to a want of saltpetre, which, on account of the vigilance of the English, could no longer be imported into France. At this crisis Bonaparte applied for aid to his friend Berthollet, who, after giving the subject a short consideration, is said to have made this confident reply, "*Sire, within three days we will make our own nitre,*"—and he kept his word.

It would be out of place here to give a detailed account of those chemical affinities on which the artificial manufacture of nitre is dependent. Suffice it to say, that both *nitrogen* and *oxygen*, the gaseous

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powder is softness of grain, but it ignites with great facility, and fires with sufficient rapidity in a percussion gun to answer all common purposes. Having secured the confidence of a gentleman of uncertain profession, who spent a great deal of his time amongst the mountain passes leading from Salobreña and Almuñecar to Granada, armed with a blunderbuss for defence, it is supposed, the writer of these pages was favoured with a private inspection of the domestic powder manufacture. A mortar was employed for braying the three components together, moistened with water, and the half dry paste was grained by pressure through a sieve; no preliminary compression having been employed, and hence the softness of grain.

materials of saltpetre, exist to an unlimited extent in the atmosphere, and that under some circumstances they unite with lime spontaneously; thus in old walls we have frequently a nitrate of lime, and by the addition of potash, or substances containing it, such as wood-ashes, to this, we obtain nitrate of potash, *nitre*, or *saltpetre*.

Napoleon, at the juncture alluded to, issued a commission for the appropriation of old walls, and other suitable materials, to the manufacture of saltpetre; and eventually lime, rubbish, wood-ashes, &c., were mingled together, in what were called nitre beds, for the sole purpose of forming this compound. Thus France was rendered independent of foreign supply.

It has been erroneously stated by some that Berthollet discovered the plan of thus preparing nitre, which was not the case. The process was known to and described by the chemist Glauber. In Prussia and in Sweden the making of nitre has been cultivated as a piece of state policy. The King of Prussia* obliged his farmers to build their fences of nitre-forming materials, which after a few years were taken down and appropriated. In Sweden,† so careful is the Government on this point, that each farmer is obliged annually to furnish a certain quantity which must be paid in kind—Government will not compound for it—

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* Considerations on the Importance of the Production of Saltpetre in England, by William Denries. Also Dumas, *Traité de Chimie.*

† Berzelius, *Traité de Chimie*, t. iii. p. 391.

thinking that by following such a course it guards against the injurious consequences which might arise during a war if the supply of nitre were drawn exclusively from abroad.

In the manufacture of gunpowder, it is of the greatest possible importance that all the materials should be of the utmost purity. Saltpetre, on its first arrival in this country, is dark, foul, and in other respects totally unadapted to the purpose. Being dissolved in water, the earthy impurities with which it is contaminated sink to the bottom of the solution; particles of dust and other light substances rise to the surface, and are skimmed off; whilst nitrate of lime, chloride of sodium, calcium, and some other salts, are gotten rid of by taking advantage of the difference between their solubility in water and the solubility of nitrate of potash. Nitre is more soluble in boiling water than in cold; chloride of sodium (common salt) is not; therefore by drawing off the nitre at a high temperature, the common salt is left behind. Again, chlorides of calcium and magnesium, the nitrates of lime and soda, are more soluble in water, hot or cold, than is nitre; therefore the latter crystallizes, leaving the former in solution. By taking advantage of these beautiful natural laws is nitre purified; one operation, however, not being always sufficient, inasmuch as the least particle of foreign salt, particularly the nitrate of lime and chloride of sodium, materially injures the resulting gunpowder, owing to the powerful attraction of these bodies for water.

After the purification of the nitre, the next operation to which it is subjected, previously to, its being manufactured into gunpowder, is fusion. This is for the purpose of driving off any water that may be *entangled* amongst its particles (nitre does not contain any *chemically united*), and thereby enabling it to be weighed with accuracy—nothing more; and it would be well if the operation could be altogether dispensed with, inasmuch as the application of too high a temperature drives off oxygen and binoxide of nitrogen, thus materially injuring the substance—indeed, partially changing it into free potash and nitrate of potash.* The fusion should never be effected by a heat greater than 500 or 600 deg. Fahr., otherwise the injurious changes take place.

We will now leave the consideration of nitre for a time, and turn our attention to sulphur, another of the ingredients employed in the manufacture of gunpowder. This substance is one of the few simple non-metallic bodies which frequently exist in nature uncombined. In all volcanic countries it is very abundant; our chief supply is from Sicily, where it is found embedded in thick masses very nearly pure, although not sufficiently so for the purposes of the powder manufacturer. To effect this purification one of two methods is employed. In the Government powder-mills the sulphur employed is simply fused, when the grosser impurities sinking to the bottom of the vessel, and the lighter ones rising to the surface, leave the intermediate sulphur more or less pure, when it can be withdrawn by a proper contrivance. Some of our private manufacturers have recourse to the same operation, but others purify their sulphur by sublimation, taking advantage of a property which this substance possesses of vaporizing at a temperature of about 170 deg. Fahr.

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* A Treatise on Naval Gunnery, by Sir Howard Douglas.

We now come to the manufacture of pure charcoal, which lately has been carried to a great perfection, to which cause, more than any other, the great superiority of gunpowder now manufactured over that of previous times is mainly attributable. Charcoal, as all are aware, is essentially *carbon*,—that chemical principle which, in a state of absolute purity, constitutes the diamond. Charcoal is formed by exposing animal or vegetable substances to elevated temperatures under circumstances which do not favour combustion; that is to say, air being totally or partially excluded. The operation of forming charcoal depends upon the fact that carbon is indestructible at any temperature, provided air be excluded. As charcoal made from vegetable substances is the kind invariably employed for the purpose of making gunpowder, we may confine our attention exclusively to that variety.

We need scarcely allude to the common plan of making charcoal, namely, by putting billets of wood into a pit, setting fire to them, then covering them with turf, &c., in such a manner that just air enough may be admitted to effect slow combustion. Until lately charcoal made by this process was employed by the gunpowder manufacturer. Very early in the history of gunpowder it was discovered that light woods, such as willow and alder, were infinitely superior to hard woods in yielding good charcoal, but facts of a chemical nature having reference to the further improvement of charcoal were not then known. When we consider how various are the secretions and juices of vegetables—how different in regard to their volatility and destructibility—how variable are the amounts of lime, potash, soda, and other bodies, some of which exist in most vegetables, and which, being devoid of volatility, must remain behind and contaminate the charcoal—it is evident that no inconsiderable amount of chemical knowledge is required in the manufacture of this substance for gunpowder.

The common plan, then, of manufacturing charcoal is found never to yield a result of the greatest possible purity: in other words, it is not possible to apply the due amount of heat, so that all volatile substances may be driven off, without at the same time partially destroying the charcoal. The process now followed is that of distillation; the wood, cut into billets of proper length and size, being inserted into cast-iron cylinders or retorts heated to the requisite degree. By this operation not only is the wood effectually charred, but acetic acid, called from its source *pyroligneous*, and *tar*, and pyroacetic spirit, valuable results which formerly were dissipated, are now saved; moreover, charcoal thus prepared is said to be more free than any other from potash—a fact which seems attributable to the action of acetic acid in dissolving it out.

For the best kind of sporting powder black dry wood is that employed; willow and alder are used for Government powder; any kind of wood is indiscriminately used for the common powder. In India the gram-bush plant (*cytisus cajan*), Parkinsonia, and milk-edge (*euphorbia tiraculli*), are found to answer well.* Whatever the wood, it should be carefully decorticated, for which purpose it is usually felled in May, when the sap is up. The reason of removing the bark is to prevent scintillation, which would be an exceedingly dangerous quality in gunpowder. All who are accustomed to see charcoal fires, must have noticed how the bark of this material shoots into coruscations; indeed, the experimental chemist carefully selects, for the purpose of showing the combustion of charcoal in oxygen gas, such portions of this substance as are supplied with bark, and which in consequence beautifully scintillate.

Having sketched the mode of purifying the ingredients of gunpowder, we will now proceed to the manufacture of this substance.

The saltpetre, melted as already mentioned, and allowed to cool into flat cakes, is taken to the mill, placed on the bed of the trough, and broken to pieces by a hammer; the mill-stones being then set in motion, it is reduced to the state of coarse powder, in which condition it is removed to another mill, very much like that used for grinding corn, and reduced to impalpable powder. The charcoal and sulphur being pulverized in a similar manner, all these ingredients are taken to the mixing house, and weighed out into the proper quantities. Then the charcoal is spread in a trough, and the sulphur and nitre being sifted upon it, all these ingredients are incorporated by the hands. The ingredients being thus imperfectly mixed, are taken to the powder-mill, which is a brick building with a light boarded roof. In the midst of this apartment is a circular trough, provided with a cast-iron or stone bed, on which revolve two mill-stones, attached to a horizontal axis, and each weighing from three to four tons. Manufacturers are forbidden by law to employ in these operations more than forty-two pounds of composition, on account of the frequent accidents which take place.

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* Braddock's Memoir on Gunpowder.

The danger varies according to the degree of trituration to which the materials have been exposed; usually, however, it is not great; partly on account of the materials not being perfectly mixed, or if mixed, not grained, and in all cases damp; a little water being purposely added during the operation, not enough, however, to form a paste. The time during which the operation must be continued differs according to the goodness of the powder required, the nature of the atmosphere, and some other circumstances. At the Government mills, the time is usually three hours, and in general terms, we may say from one to six hours. Time, however, is never made a criterion, but great attention is paid to a plasticity which the mass ultimately acquires, when, in the workman's language, it is said to be *alive*. It then glides from beneath the stones without attaching itself to them, and, under the name of mill cake, is broken up and conveyed to the press-room.*

The next operation consists in spreading this mill cake on alternate copper plates, in layers of three inches thick, until the press is full, when a compressing force is applied either by the screw and capstan, or by Bramah's hydrostatic engine. The latter was first employed for this purpose by Sir W. Congreve, and of course is much more powerful than any other; but it is found that the extremity of compressing force capable of being exerted by this machine must not be applied, for in that case the mass is rendered so compact as materially to interfere with the rapidity of combustion—in other words, the resulting powder is deteriorated.

The next operation is that of corning, or graining—a very ingenious contrivance, without which gunpowder would burn so slowly as to be inapplicable to most purposes. The graining is accomplished in the following manner:—In the graining house are sieves, the bottom of which are made of thick parchment, prepared expressly for this purpose from bullocks' hides, and perforated with small holes. These sieves are so arranged that they can be put in rapid circular motion by the aid of machinery, and each sieve contains two discs of lignum vitæ. Into the sieves is placed the mill cake just described, which, by the circular motion to which it is subjected, and the friction of the discs of lignum vitæ, is forced through the minute holes of the parchment in the state of grains. These, however, are not all of the same size, but require to be separated into various lots by the agency of different sieves.

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* Formerly a pestle and mortar were employed for the purpose of incorporating the materials. See Hanzelet, *Recueil de plusieurs Machines Militaires*, &c., 1620, p. 15, plate. On a larger scale a kind of fulling mill was used. See *Modelles Artifices de Feu*, &c., par Boillet Langrois, 1620, p. 98. A modification of this latter apparatus seems to be used now by preference in France, under the name of *Pilon Mill.—Memoir on Gunpowder, by* John Braddock, *Esq.*, 1832, p. 47.

The next operations are drying* and *glazing*, without the latter of which gunpowder would look dull. Glazing is accomplished by placing the grains in a barrel fixed on a horizontal axis, and made to revolve with great velocity. It will be seen, from this, that the glazing is due to friction, consequently some powder dust must result. This is separated from the grains by means of a gauze cylinder, into which the whole material is put, and subjected to violent rotation, during which the dust flies off, and the polished grains remain in the cylinder. The operation is now finished.

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* Drying is now usually conducted by steam, at a temperature of just sufficient to drive off the water, but far from melting the nitre and sulphur. Hence gunpowder is always more or less attractive of moisture. Lieutenant Bishop (*vide* Braddock, *sup. cit.*) proposed the daring scheme of exposing gunpowder, at its last stage of manufacture, to a temperature of 500 deg. Fahr., by which the nitre and sulphur entering into its composition might be actually melted, and thus envelope the charcoal in a dense coat! Gunpowder thus prepared would certainly be less hygrometric than usual, but *we* would rather not be engaged in manufacturing it.

Most persons are aware that cannon and mining gunpowder is not so finely grained as that for muskets, and this not so finely as gunpowder intended for fowling-pieces. Fineness of grain increases the rapidity of ignition, a quality necessary for the projection of small weights, whereas a certain tardiness of ignition is requisite for the projection of large balls and shells, mining, &c. It would, perhaps, be more correct to say, that the fineness of the grain should always be in proportion to the quantity employed. If several pounds of powder be used for the purpose of projecting a ball, the large grained variety will be found to accomplish the greatest distance: if only, on the contrary, a few ounces, the small grained has the preference.*

Seeing the great amount of mechanical skill requisite to form gunpowder, and the chemistry which is involved in purifying its ingredients, it will perhaps be interesting to ascertain how our ancestors managed to form this compound. The earliest descriptions we have been enabled to find relative to this subject are of the years 1540,† 1588,‡ and 1620.||

With regard to the proportion of ingredients in ancient gunpowder, we shall treat more fully hereafter.

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* Wilkinson on Engines of War, p. 176.

† Biringuccio (Vanucchio), *De la Pirotechnia*, 4to, Venetia, 1540.

‡ Machiavelli Nic. The Arte of Warre, transl. by Peter Whithorne, 1588, p. 27.

|| Hanzelet's *Recueil de plusieurs Machines Militaires*, &c., 1620, p. 15; and *Modelles Artifices de Feu*, &c., par Boillet Langrois, 1620, p. 86.

At present let us direct our attention to the mechanical details of preparing it. Those of our readers who are aware of the extent to which gunpowder may be modified, merely by more or less perfect mixture and graining, the composition remaining the same, and who can appreciate the numerous ingenious mechanical resources which modern ingenuity has enabled the manufacturer of gunpowder to avail himself of, will be prepared to expect that the ancient powder must have been very deficient in many of those qualities necessary to constitute perfection. Our forefathers, however, proceeded very ingeniously to work, as we shall see. In the first place, they prepared charcoal of exquisite fineness by burning the softest woods—nay, sometimes linen rags and straw; the latter substance, however, is decidedly improper, owing to the large amount of silicic acid, or flint, which it contains. Their sulphur was purified by sublimation, like a good deal of ours, and then they obtained it in a state of impalpable powder. Their treatment of the saltpetre was, however, quite different from that of ourselves. Every one conversant with chemistry is aware that this salt may be obtained in a state of impalpable powder by dissolving the crystals in the smallest possible quantity of water, then applying heat to vaporize this water, stirring the solution all the time incessantly. Now, the ancient gunpowder manufacturers very ingeniously took advantage of this circumstance to secure perfect mixture of the three ingredients. The saltpetre was first dissolved, then, the sulphur and charcoal being added, the mixture was stirred assiduously, by which means all three ingredients were mixed very effectually. As for the graining, our forefathers must have succeeded but indifferently; the mixture was moistened with vinegar, wine, brandy, more frequently than water; indeed this process was thought to add strength to the powder, and it was imagined that vinegar, wine, brandy, &c., being what are popularly called *strong* fluids, were necessarily more efficacious than mere water. Various other nostrums were also occasionally added in this stage, all detrimental, however, to the resulting powder.* The next stage consisted in granulation, no previous condensation by pressure having been thought necessary, or perhaps the process had not been thought of.† The granulation was conducted exactly as at present.

Now it follows from a consideration of the foregoing circumstances, that, however pure might have been the ingredients, however intimately mixed, the grains of powder must have been deficient of hardness and tenacity, and hence the result must have been very imperfect. That such was the case is evident enough, from the reiterated directions which are given in all ancient books treating of gun practice, not to bruise the grains by ramming too hard.*

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* Machiavelli, transl. by Whithorne, lib. ii. chap. xxiii. For an account of the ancient gunpowder manufacture, the reader may also consult Biringuccio, *De la Pirotechnia*, Hanzelet's *Recueil de plusieurs Machines Militaires*, and Boillot Langrois' *Modelles Artifices de Feu*, &c. In the two latter works the process is illustrated with cuts. The first of the series in Boillot Langrois represents a monk weighing out the ingredients, assisted by a somewhat unworthy colleague for a divine, *i.e.*, *the Devil.*

† Although pressure is now invariably employed previously to graining, the projectile force of the gunpowder is thereby diminished; however, it is rendered more compact and less hygrometric and light than before — advantages more than compensatory for a deficiency of range. See Braddock's Memoir, p. 58.

It would be interesting to ascertain where gunpowder first began to be grained, for unquestionably this circumstance must have greatly enlarged the sphere of its application. This, however, we have been unable to determine. The earliest descriptiors of gunpowder manufacture which we have been enabled to find are those already quoted, and were written at periods when its manufacture must have been subjected to great improvement.

It should be mentioned, that so long as matchlocks were used, the powder used for priming was *literally* powder—in other words, it was not grained. This was called *serpentine powder*, deriving its name from that part of the lock which retained the match, and termed the *serpentine;* it corresponds to what we call the *cock.*

We have hitherto paid no regard to the relative quantity of ingredients in ancient gunpowders,—the proportions varied exceedingly at different times, as will be seen by the subjoined examples.

Tartaglia, in his *Quesiti e inventioni diversi,* lib. ii. Ques. 5, Venetia, 1546, gives twenty-five different compositions for gunpowder. We subjoin the first and the last—which at the same time are the strongest and the weakest.

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* Machiavelli, *Op. cit. passim.*

POLVER DI BOMBARDA AL MODO PIU ANTIQUO.

Salnitro . . . parte	1
Solfero	1
Carbone	1

POLVER DA SCHIOPPO MODERNA.

Salnitro raffinato . . parti	18
Solfero	2
Carbon de legno de nizzolar .	3

Machiavelli has copied these tables in full. See Whithorne's Translation, p. 31, lib. ii.

Both these compositions must have yielded a very imperfect powder; it is difficult to imagine that the first could have had any projectile effect at all formidable.

Some of the other proportions, moreover, would yield powders scarcely more powerful than the composition of a squib, and altogether inapplicable to the purposes of modern warfare. We must not conclude, nevertheless, that this circumstance arose from ignorance of better proportions; a far more plausible explanation of the fact is, that guns were then so weak, that stronger powders would have destroyed them. No doubt the proper ratio of ingredients to form good gunpowder can be determined *à priori*, from a consideration of chemical laws; yet it is a remarkable fact, that some time before chemistry was thus far advanced, manufacturers had, by dint of mere experience, discovered the best proportions; that the chemist in this respect cannot lend them any aid. The last great improvement in gunpowder consisted in the use of the cylinder charcoal already mentioned, when the material thus formed acquired such additional strength that the proportion of charges used for ordnance was in consequence reduced one-third.*

If gunpowder, as now prepared, have any fault, it consists in being rather *too strong.* Were it desirable, its strength, by mere peculiarities of manipulation, might be still further increased, without any alteration of the ingredients or their proportions—indeed, Sir William Congreve did make some of this gunpowder, but it was found to explode on percussion, besides being in other respects highly dangerous, and therefore inapplicable. Those persons who anticipate the accomplishment of a long range by the use of dangerous fulminating compounds, hereafter to be described, should well consider this fact. We here subjoin a table of the composition of gunpowder for different purposes, and the chemical results of its inflammation:—

MINERS' POWDER.

→	Atoms.	Theory (per cent.)	Practice (per cent.)	Results of Combustion.	Atoms.
1 Nitre .	102	63·35	65	1 Bisulphuret of Potassium .	12
2 Sulphur	32	19·87	20	1 Nitrogen . .	14
4½ Carbon	27	16·77	15	1½ Carbonic Acid	33
				3 Carbonic Oxide	42
Total .	161	100·00	100	Total . .	101

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* Phil. Trans., vol. ix. p. 358, Coleman's paper.

FINE SHOOTING POWDER.

—	Atoms.	Theory (per cent.)	Practice (per cent.)	Results of Combustion.	Atoms.
4 Nitre .	408	77·71	78	3 Sulphuret of Potassium .	168
3 Sulphur	48	9·14	10	1 Carbonate of Potash .	70
11½ Carbon	69	13·14	12	4 Nitrogen .	58
				10½ Carbonic Acid	231
Total .	525	99·99	100	Total . .	525

COMMON SHOOTING POWDER.

—	Atoms.	Theory (per cent.)	Practice (per cent.)	Results of Combustion.	Atoms.
1 Nitre .	102	75	75	1 Sulphuret of Potassium .	56
1 Sulphur	16	11·76	12·5	1 Nitrogen . .	14
3 Carbon	18	13·23	12·5	3 Carbonic Acid	66
Total .	136	99·99	100·0	Total . .	136

The enormous force of inflamed gunpowder is known to depend on the evolution of various gases, the volume of which, when cooled, it is easy enough to determine; but at the moment of their formation they are vastly dilated by heat, so that their actual effective volume and pressure cannot be justly ascertained. It has been pretty correctly ascertained that a cubic inch of gunpowder is converted by ignition into 250 cubic inches of *permanent* gases, which, according to Dr. Hutton, are increased in volume eight times at the time of their formation by the expansive influence of heat. Assuming these data to be true, confined and ignited gunpowder will exert, at least, a force of 2,000 lbs. on every square inch!

Before concluding our notice of gunpowder, it may not be amiss to point out certain indications of its good and bad qualities. Its colour should be rather brown than black; the grains should be firm, not crushing by the pressure of the finger, not clotted together, and totally devoid of smell. Such are the physical qualities of good gunpowder; its chemical characteristics shall be mentioned presently. The disagreeable smell which sometimes arises from bad gunpowder depends on the application of an undue amount of heat in the fusion of the nitre. This effects the decomposition of the salt, causing it to yield up the elements of its acid, either totally or partially, thus leaving nitrate of potash and free potash as residues. Thus, not only is the resulting powder weakened by the absence of the requisite quantity of nitre, but potash is itself deliquescent, and moreover, by reacting on the sulphur, forms sulphuret of potasium; this, in its turn, reacting on aqueous moisture, yields hydro-sulphuric acid gas, to which the disagreeable odour alluded to is attributable. The simplest plan of analyzing the gunpowder (as to the relative proportions of its true ingredients) is by first dissolving out the nitre by means of pure water, then the sulphur by aid of a solution of potash, thus isolating the charcoal. Each of these substances, when dry, may be weighed.

The solution of nitre should neither precipitate nitrate of silver (indicative of the presence of common salt and carbonate of soda), nor blacken a solution of acetate of lead (indicative of the presence of hydro-sulphuric acid), nor change turmeric paper brown, nor litmus paper red; the former would be indicative of an alkali, the latter of an acid.

We have seen that mechanical aid contributes no less than chemistry to the perfection of gunpowder; therefore other means of forming a judgment, in addition to chemical tests, become necessary. Manufacturers are in the habit of paying great attention to the manner of its burning, whether it ignite rapidly or slowly, whether it scintillate or not, whether it leave much residue, and on the contrary, &c. &c. There are also instruments called *eprouvettes* for ascertaining the comparative force of powder; but in our Government service the force of gunpowder is ascertained by trying the power of a given quantity in projecting a known weight. A charge of four drachms of fine-grained or small-arm powder is expected to project a steel ball with the requisite force to perforate a certain number of half-inch wet elm planks, placed three-quarters of an inch asunder, the first being thirty feet from the muzzle of the barrel.* A charge of four ounces of cannon powder must be capable of projecting, from an eight-inch Gomer mortar, a sixty-eight pound iron shot not less than 380 feet.*

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* The Government powder labelled T.P.F., when new, propels the ball through fifteen or sixteen boards; and when restoved, through nine to twelve. — WILKINSON, *Op. cit.*, p. 175.

Few persons can be aware of the enormous quantities of gunpowder used for military purposes. At the siege of Ciudad Rodrigo, in January, 1812, 74,978 lbs. of gunpowder were consumed in thirty hours and a half; at the storming of Badajos, 228,830 lbs. in 104 hours; and this from the great guns only!† At the first and second sieges of San Sebastian, 502,110 lbs.‡ were used; and at the siege of Zaragossa, the French exploded 45,000 lbs. in the mines, and threw 16,000 shells during the bombardment!‖

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* Wilkinson on Engines of War, p. 195.

† The British Gunner. Quoted by Wilkinson, Engines of War, &c., 148.

‡ From the returns made to the Royal Arsenal, Woolwich.

‖ Napier's History of the Peninsular War. Wilkinson, *Op. supra. cit.*, p. 148.

ON THE APPLICATION OF GUNPOWDER TO MILITARY PURPOSES.

THIS subject is, as we have already remarked, distinct from the discovery of gunpowder; it may be considered under the following heads:—

The application of gunpowder to the purpose of projecting weights from tubes.

The application of gunpowder to the purposes of mining.

The application of gunpowder to effect the bursting of hollow spheres—called shells, grenades, &c.

The application of gunpowder in elaborating the rocket.*

When treating of the history of gunpowder, we carried its invention, by reference to documents, to a period anterior—how much we know not—to the period of Marcus Græcus, or Gracchus, who lived in the eighth century. We mentioned, however, the probability that it had been known in Asia from time immemorial, and quoted several treatises having reference to this subject. Without alluding to the latter again in detail, it may be sufficient to remark, that not only do they allude to gunpowder, but also in most instances to guns: this remark applies most particularly to the Gentoo laws, which were printed by the East India Company in 1776. Whatever truth, however, may be accorded to those oriental documents (and we consider that collateral testimony is in favour of their credibility), it is certain that the period when fire-arms were introduced from Asia into Europe is either forgotten, no record of it having been made, or that the European employment of these weapons was altogether due to a fresh discovery. Marcus Græcus, although he mentions gunpowder and its application to many pyrotechnical devices, says nothing about its application to guns, which can scarcely be accounted for on any other supposition than that he was unaware of their existence.

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* Chemically speaking, the material for filling rockets *is gunpowder*—*i. e.*, a mixture of nitre, sulphur, and charcoal, although the proportions of these ingredients are different from common gunpowder.

This circumstance is in favour of the opinion that the employment of fire-arms in Europe was the result of an European discovery. Another circumstance may be mentioned to the same effect, although it does not rest on very good testimony.

The reader has already been made aware that the Germans claim the invention of gunpowder for their countryman Bartholdus Schwartz. We have already discussed that claim, and proved that he has no pretensions of the kind whatever;—this is indisputable, yet it does not seem so clear that he might not have originated the idea of applying the force of gunpowder to missile weapons. It is said that this individual was operating in a mortar on a mixture of nitre, charcoal, and sulphur (gunpowder, in fact)—that the mixture exploded, urging the pestle to a considerable distance, —that hence originated cannon, and also the military term *mortar* as applied to a particular variety of cannon.

All this seems plausible enough, and may be true; but seeing that the use of fire-arms first became prevalent in Europe in those countries which mixed with the Saracens, and that cannon are described by Arabian authors as early as 1312; considering, moreover, the scientific character of this people, and duly weighing the testimony of oriental nations, we are constrained to lean to the opinion that fire-arms were not re-invented in Europe.

Guns may be divided into artillery (in its modern acceptation) and small arms; not that the division is very correct, inasmuch as ancient small arms were *all cannon*, yet the division will answer our purpose.

The term CANNON is most probably derived from *καννα*, or in Latin *canna*, a reed, although some persons refer it to the Greek *κανὼν*, signifying the beam of a steel-yard, a reed, cane, rod, &c. Older military writers make use of the term cannon just as we do *barrel*, including that part of all fire-arms, whether large or small. We restrict it to artillery.

The first cannon were called bombardæ, from *βομϐος*, or *a bombo et adore*, on account of the great noise which the firing of them occasioned.

A very few words will suffice to express all we know relative to the first employment of cannon in European warfare. It is generally believed that they have been commonly employed since the year 1338; at least Father Daniel, in his Life of Philip of Valois, seems to have proved this from the records of the Chamber of Accounts at Paris. Du Cange, indeed, finds them mentioned in Froissart and other French historians some time earlier. Although the French employed cannon in 1338, for the purpose of demolishing some castles, they did not use them in the field so soon as the English, who, in 1340, under Edward III., placed five of them on a small hill near the village of Creçy;* and this, it is said, contributed not a little to the success of that celebrated battle. This circumstance has been quoted by some French authors as a proof of our greater *barbarity*, in setting the example of killing our fellow-creatures by such murderous engines.

"On ne faisoit" (says one of them) "point encore usage en France, en 1547, de cette arme terrible contre les hommes; les Français s'en étoient bien servis in 1338, pour l'attaque de quelques châteaux, mais ils rougissoient de l'employer contre leurs semblables. Les Anglais, moins humains, sans doute, nous devancèrent et s'en servirent à la célèbre bataille de Creci, qui eut lieu entre les troupes du roi d'Angleterre, Edouard III., qui fut si méchant, si perfide, qui donna tant de fil à retordre à Philippe de Valois, et aux troupes de ce dernier; et ce fut en majeure partie à la frayeur et à la confusion qu'occasionnèrent les canons, dont les Anglais se servoient pour la première fois, qu'ils avoient postés sur une colline proche le village de Creci, que les Français dirent leur déroute."

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* This fact is doubted by some. Froissart does not mention it, which is not easy to account for, if it were true. We have, however, the testimony of Petrarch to show that cannon were common before the year 1344, *nuper rara nunc communis*. According to Babour, Edward III. was supplied with cannon as early as 1327.

In the time of Henry III. of France, the use and practice of artillery was still in its infancy; D'Etrees, the master-general of the ordnance in 1558, was the first who made any progress in the construction of batteries. Before his time, continual accidents occurred from the bursting of cannon, and it was usual to cool them with vinegar, in order to prevent these misfortunes; scarcely a worse plan could have been followed. Armies were at this period but slenderly provided with cannon, which were thought chiefly necessary for sieges; at least such was the opinion in France.* In England, however, the science of artillery was further advanced; and Lord Herbert observes, that in 1544 Henry VIII. had invented small pieces of artillery to defend his wagons.† When cannon were drawn by horses instead of oxen, and could keep pace with a moving army, it was thought to be a great achievement.

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* Wraxall's History of France, vol. ii. p. 249.

† Figures of these gun-wagons may be seen in Grose's Treatise on Military Armour.

Before the fifteenth century, cannon were designated by various fanciful names; then, however, they began to be indicated by the weight of their balls, as at present. Much celebrity was formerly acquired by several cannon in various countries, but the most famous of all seems to be that enormous gun used by Mahomet II. against the Greeks, at the siege of Constantinople, in 1453. It was cast at Adrianople, by a Dane or Hungarian named Urban, who had deserted from the Emperor Constantine Palæologus. It is thus described by Gibbon: "At the end of three months, a piece of brass ordnance was produced of stupendous and almost incredible magnitude; a measure of twelve palms is assigned to the bore, and the stone bullet weighed above 600 lbs. A vacant place before the palace was chosen for the first experiment, but to prevent the sudden and mischievous effects of astonishment and fear, a proclamation was issued that the cannon would be discharged on the ensuing day. The explosion was felt or heard in a circuit of 100 furlongs; the ball, by the force of gunpowder, was driven above a mile, and on the spot where it fell it buried itself a fathom deep in the ground. For the conveyance of this destructive engine a frame or carriage of thirty wagons was linked together, and drawn along by a team of sixty oxen; 200 men on both sides were stationed to poise and support the rolling weight; 250 workmen marched before to smooth the way and repair the bridges, and near two months were employed in a laborious journey of 150 miles."

Any person who has the slightest mechanical knowledge must be aware that the formation of a cannon, or indeed of any other fire-arm, is necessarily a somewhat difficult task, requiring various mechanical contrivances only to be met with in comparatively civilized countries. It is not to be wondered at, therefore, that the resources of our ancestors were but slightly inadequate to this end. The first cannon employed were nothing more than bars of iron arranged in such a manner that their internal aspects should form a tube; the bars were not welded, but merely confined by hoops. On some occasions, expedients much less efficient than this have been had recourse to; cannon having been made of coils of rope arranged in a tubular form, and even of leather, or of wood. Of course nothing like perfection of form or bore was then attempted, indeed was not desirable, inasmuch as no amount of science, either mathematical or chemical, was then applied to artillery practice.

Cannon seem long after their first invention to have been regarded with a sort of awe and mystery—the flight of their projectiles was considered to be totally different from all other projectiles, and the wounds occasioned by fire-arms generally, were thought to be all but necessarily mortal.[*]

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[*] This might easily be accounted for by the unskilful surgery of those days. The army surgeons were assuredly the most effectual of all destructive engines. We remember meeting with a recipe for a gunshot wound, which we cannot now recollect in its details, neither can we fix on the authority. The

Tartaglia, whom we formerly quoted in reference to the composition of gunpowder, was the first to apply mathematical reasoning to the practice of artillery;* he took considerable trouble to prove the now well-known fact that no portion of the flight of a cannon-ball was a straight line, but that a curve was described from the very beginning of its course; he moreover proved, that a cannon shoots furthest at an elevation of 45 deg. Tartaglia, moreover, is reputed to have discovered the gunner's quadrant.

It remained for the great Galileo and his pupil Torricelli to investigate more narrowly the law of falling bodies. Tartaglia proved that a cannon-ball, when shot from the gun, moved in a curve; Galileo determined that this curve was the parabola, provided the ball fell on the same place as the battery from which it was shot, and that the gun was elevated above the horizon; he proved, moreover, it was *half* a parabola, provided, under the same circumstances, the gun were pointed horizontally.

Torricelli extended these discoveries; he showed that whether the ball fell above or below the plane of its projection, it described a parabola of smaller or

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prescription was, however, somewhat to this effect:—Take of oil and of wine equal parts, boil them, and then project into them a dog yet living; the animal was to be well boiled, and his flesh, together with the oil, wine, and other ingredients, formed the application!

* See his *Nova Scientia*, published at Venice, in 1537, and his *Quesiti ed inventioni diversi*, Venice, 1546.

larger amplitude, according to the angle at which the gun was elevated, and the strength of the powder.

Before the time of Galileo, artillery practice was imperfect, chiefly because no mathematical knowledge whatever had been applied: after the time of this philosopher, artillery practice was imperfect, chiefly because his views were too exclusively adopted, without attaching due importance to collateral and interfering causes.

Moving as we do slowly through the atmosphere, which cleaves and mingles again so that it has become the very type of non-resistance, we are scarcely competent to judge of the immense force which it exercises against a projectile moving with great velocity. Galileo's experiments were performed with slowly moving bodies, on which atmospheric resistance could have had but little effect, so that the parabolic curve would have been but slightly departed from; hence he did not fully appreciate the influence attributable to this cause. Galileo, however, was not unaware that the air really did exercise some resistance, but he believed it to be more insignificant than it is.

The views of Galileo were adopted almost universally. Our countryman Anderson* laboured hard to prove their correctness, and M. Blondel, in France,† maintained a similar opinion. Dr. Halley, in 1686, expressly asserts, that "in large shot of metal, whose weight many times surpasses that of the air, and whose force is very great in proportion to the surface wherewith they press thereon, this opposition is scarce discernible," and he infers from the result of observation, that "although in small and light shot, the opposition of the air ought, and must be accounted for, yet in shooting of great and weighty bombs, there need be very little or no allowance made."* Artillerists might have been led to doubt the truth of this determination of Dr. Hutton, by the authority of a still greater name—Sir Isaac Newton, who, in 1687,† demonstrated that the curve described by a projectile, in a strongly resisting medium, differed from a parabola; and that the resistance of the air was great enough to make the difference between the curve of projection of heavy bodies and a parabola far from being insensible, and therefore too considerable to be neglected. Huygens in 1690 made a similar statement.

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* Genuine Use and Effects of the Gunne, 1674.

† *Art de jetter les Bombes*, Par. 1683.

Notwithstanding the testimony of two such names, and better testimony still—that of practice, the error of Galileo continued to be propagated. Blondel had calculated tables according to this theory, and they were pronounced incontrovertible.

In 1716, however, M. Ressons, a French artillery officer, did not hesitate to assert, in a memoir presented to the Royal Academy,‡ that theory was of very little service in the use of mortars, and that practice had convinced him there was no theory in the effects of gunpowder.

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* Phil. Trans., No. 179, p. 19.

† *Principia*, lib. ii. § 7.

‡ *Discours de la Cause de la Pesanteur*, Leide. 1690.

It may be asked, why it was that the errors of the parabolic theory were perpetuated, when there was so easy a test as actual practice to determine their value? The answer is, that many were paralyzed by the great name of Galileo, and did not venture to think for themselves; others there were who attributed the want of accordance existing between theory and practice, to some interfering cause;—anything, however, but the true one.

Our countryman Anderson, whom we have quoted more than once, endeavoured to strengthen the doctrine of Galileo by appending to it a very curious one of his own. He granted that cannon-balls, like other projectiles, ultimately began to describe in their course the parabolical curve—but that, before they did this, they continued to be impelled for a certain period in a perfectly straight line, which he termed *the line of the impulse of fire.* In this state of uncertainty did this theory of projectiles remain, until Mr. Robins published, in the year 1742, his treatise, called "New Principles of Gunnery." The principles developed in this treatise were soon after confirmed by M. Euler, of Berlin; M. Leroz, of Paris;* and by Dr. Hutton.

It does not form part of our scheme to detail the various experiments or mathematical calculations by which Mr. Robins arrived at his celebrated result; we may mention, however, this much generally, that having devised experiments and made calculations, which at this day are admitted to be correct, at least in all their leading particulars, he proved that the parabolic theory, as applied to projectiles urged with slow velocities, was not far at variance with practice, but that this theory, when applied to rapidly moving bodies, such as shot and shells, was utterly false; that the fallacy was occasioned by atmospheric pressure chiefly, and that this pressure increases with such enormous rapidity, as compared with increase of projectile force, that the ratio between the two could not be calculated.

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* *Mém. Acad. Scien.* for 1751.

If this assertion be true (and no one at all conversant with the subject doubts it), what becomes of the opinions—the visionary hopes of those who think to accomplish unheard-of ranges by increase of projectile force? Granting that the atmosphere exerts a resistance increasing with the velocity of a ball, it is evident that a point at length is arrived at, when both these forces, namely, the projectile force of the ball and the resistance of the atmosphere, are equal—beyond this no increase of projectile force can increase the ranges; simply because in the same ratio as an explosive material, be it gunpowder or anything else, urges a body forwards, the air forces it back. These are the limits of theory, but in practice we cannot go so far. We have supposed it possible to find cannon strong enough to withstand this projectile effort—balls strong enough to resist the shock without breaking—

and gunpowder possessing just that degree of force, neither more or less:—all this is out of the question.

These arguments have tended to prove the impossibility of accomplishing more than a given range, by any increase of *initial* power whatever; *we do not assert that such range may not be increased by other appliances*—this consideration will be reserved for a later period. Let us now proceed to observe, that the public, at least the non-chemical portion of it, attach a very wrong signification to the words *strong* and *strength;* for instance, oil of vitriol is said to be a strong substance, and water a weak one; yet a chemist has great difficulty to understand what is meant by such an application of the term.

The words strong and strength are, in point of fact, very fallacious, and, therefore, the notion which the public have of projectile weapons and projectile compounds, is, among other things, very incorrect.

An ounce of gunpowder fired loosely scarce makes a noise; a little smoke, a little fire, a little smell of sulphureous gas, and all is over; yet the same ounce of powder, in a musket, would be a large charge, far more than necessary to urge with deadly effect a heavy leaden ball.

An ounce of fulminating silver, on the other hand —nay, but who would dare to handle an ounce of such a substance?—say the *ninety-sixth part of an ounce,* or just five grains; well, five grains of fulminating silver are taken out of a paper, with much trembling, touched with no hard substance, for fear of explosion, then gently laid on a piece of metal—say a penny piece;—then, suppose it ignited by means of a very long stick, with a match at one end; and—begging the operator's pardon—with a somewhat rash man at the other;—what is the result? A terrible crash, which deafens the operator for some days, and the penny piece is almost bent double! "How strong!" exclaims a non-chemical operator; "how well this will project a ball." He tries a small charge in a musket, and what are the results? why, the gun is burst, the iron literally rent into threads and fragments, the ball perhaps *is* projected, but to a very inconsiderable distance; if of lead, flattened as if by a hammer; if of cast iron, *broken into fragments!* Now, which shall we say is the stronger substance, gunpowder or fulminating silver?*

The force of all explosive bodies depends on the gases which are liberated during explosion, and the peculiar effects of their explosion depend on two separate circumstances, the total quantity of gas eliminated, and the rapidity of its elimination. Gunpowder, perhaps, compared weight for weight with fulminating silver, liberates more gas of the two, but not so rapidly—the liberation is progressive, not instantaneous; hence its immediate disintegrating effects are not so considerable as those of fulminating silver, but as a projectile agent it is more efficient. We just think of one more case, which will tend to show how different are the requisites for mere impulse and prolonged motion. Suppose a railway carriage on the line, ready to move on the application of proper force; suppose now a sixty pound cannon-ball to be fired at it *directly aft,* as the sailors would say, the carriage would have a tendency to move forward; yet, instead of doing so, it is shattered to pieces. One single man, however, applying his force, pushes it forward with great ease. Which agent, then, is the stronger of the two, a man, or a sixty pound cannon-ball in full flight? The question is unmeaning, yet not more unmeaning than many others of its class often asked by the non-scientific public. We trust, then, that we have shown that not even is there a theoretical limit to the rate of motion of a projectile, but that practically this extreme limit even cannot be attained; partly because of the want of cohesive strength in cannon and cannon-balls, partly because the quantity of gunpowder necessary to effect this would be inconvenient; and partly because all other explosive compounds are inapplicable.

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* Chemists are acquainted with two kinds of fulminating silver. The kind here alluded to is the white compound termed, in chemical language, the *fulminate of silver*. It is far less dangerous than the dark or ammoniacal fulminating compound, which, when made, can scarcely be removed from the containing vessel, so prone is it to explode.

At this period it will not be necessary to point out elaborately all the reasons which could be adduced to prove how incorrect is the *practical* application of the parabolic theory; the first and best, and only one necessary to disprove the doctrine, is, *that practice will not confirm what theory pronounced to be true*—in all cases this evidence is enough. We shall not mention any other reason, as tending to confirm an opinion—but as inevitably leading to the same conclusion by an independent train of reasoning; and at the same time affording us important guidance for our judgment of a future question not yet proposed; namely, granting the possibility of a range of six or twelve miles, to be accomplished by an initial impulse; what will be the amount of correctness with which the flight of such a projectile can be directed?

It is evident that if no resistance save that of gravitation impeded the flight of a projectile, the trajectory curve should be merely vertical; that is to say, supposing the projectile to be spherical, and homogeneous in such a manner that its centre of gravity and spherical centre might correspond. True it is that such a correspondence is not possible to be effected,—and consequently, the trajectory curve may be partly vertical, partly horizontal, even supposing the ball to fly *in vacuo*. Deviation, however, from this cause should be very slight, and should increase in proportion to the distance from the mouth of the piece only. This, however, is contrary to experience,—the same piece which will carry its bullet within an inch of the intended mark at 10 yards distance, cannot be relied upon to 10 inches in 100 yards, much less to 30 inches in 300 yards. This has been proved beyond doubt by Mr. Robins, who found that a perfectly fixed musket barrel would, when fired, project a ball with an accuracy, at 180 feet, sufficient to hit a mark one-seventh of a foot square, 15 times out of 16; yet, at a distance of 700 yards, the balls not only varied as to their vertical plane, but sometimes went 100 yards to the right or left of the intended line.

Although we have attributed this great deflection chiefly to the air, we have not said how it is occasioned. It is partly attributable to the fact, that balls cannot be made without inequalities on their surface, on which the air must therefore act unequally; but the chief cause seems to depend on the irregular whirling motion which the ball acquires on leaving the gun, and which causes the ball to present its surface to the air in a direction very different from what it would do if there were no such whirl. Deflections from the causes enumerated will occur even if the ball fit the barrel perfectly. But there is yet another usual cause of deflection, namely, windage, as the space is called between the shot and the barrel. This we shall allude to hereafter.

All these remarks concerning the irregular flight of projectiles, came under our notice incidentally in connection with the Galilean theory of the parabola. Before, however, returning to the historical portion of our subject, we will lay before the reader a table of atmospheric resistance, &c., to the flight of balls.

TABLE OF THE MOTIONS OF A 24 LB. SHOT PROJECTED AT 45 DEG. OF ELEVATION.

Velocity per second.	Range *in vacuo.*	Range in Air.	Range corrected.	Height to which the ball rises.
Feet.	Yards.	Yards.	Yards.	Yards.
200	415	320	330	100
400	1,658	1,000	1,019	300
600	3,731	1,391	1,419	400
800	6,632	1,687	1,719	464
1,000	10,362	1,840	1,878	515
1,200	14,922	1,934	1,978	561
1,400	20,300	2,078	2,129	606
1,600	26,528	2,206	2,264	650
1,800	33,574	2,326	2,391	694
2,000	40,450	2,438	2,510	738
2,200	50,155	2,542	2,622	778
2,400	59,688	2,640	2,726	816
2,600	70,050	2,734	2,823	852
2,800	81,241	2,827	2,916	887
3,000	93,262	2,915	3,002	922
3,200	106,111	2,995	3,085	996

The first column in this table contains the velocity in feet of a 24 lb. shot, projected at an angle of 45 deg.; the second column shows the distance in yards to which the ball would go *in vacuo* on a horizontal plane; the third column contains the distance to which it will range through the air, considered all of the same density as at the earth's surface; the fourth shows the same range corrected for the diminution of the air's density as the ball ascends, and is therefore called the corrected range; and the fifth column shows the height to which the ball rises in the air, or the height of the vertex of the curve above the plane.

It may be observed by reference to this table, how immense is the difference between the motion of projectiles in air and *in vacuo*, especially at large velocities. It is seen that the ranges instead of increasing in a duplicate ratio of the initial velocities, as *in vacuo*, really increase much slower; in all cases of military service, and in the most useful cases, viz., from 800 to 1,600 feet, they increase nearly as the square roots of the velocities.

Had it been our intention to write a treatise on artillery, together with the manufacture of cannon, &c., the present portion of our subject would be vastly extended; such an idea, however, is altogether foreign to our views. We have thought fit to omit altogether the description of those fanciful names which were originally applied to cannon, and we do not think it necessary to describe all the varieties of this arm which are used at present in the naval and military services of this and other countries. The carronade, howitzer, and mortar, however, are varieties which cannot with propriety be omitted. It is obvious that various requisites are necessary for different purposes to which cannon may be applied. For penetrating walls, we require heavy balls moving at great velocities, the range being point blank; for dismounting cannon and slaughtering troops, longer ranges, higher angles, and smaller velocities, are more efficacious. For field service, the portability of a cannon becomes a chief requisite; at sea this is not so essential. The reader will see, then, that cannon must necessarily vary a great deal as to length, bore, and other details of construction. With such questions we have nothing to do: those who may wish to become acquainted with this subject, we must direct to systematic works. The three kinds of artillery, however, which we have mentioned, involve not merely mechanical detail, but important principles.

We will first describe briefly the CARRONADE, which derives its name from first having been made at the Carron foundry. It is a short cannon, of large calibre, made as thin as possible consistent with safety; chambered[*] and intended to project balls or shells with small charges. Besides these essential peculiarities, the carronade is not mounted like common guns, but stands on a grooved platform. The advantages of the carronade are, that, from its exceeding lightness, it may be employed by small ships, and on their upper decks, where much weight of metal is inadmissible,—although the locality is most advantageous as an attacking position; and it requires fewer men to work it, is managed with greater rapidity than common ordnance, and on account of the small charge of powder employed in loading it,[†] the ball is urged with diminished velocity, and hence with greater shattering effect. It was owing to this latter circumstance, that originally this piece of ordnance was termed a smasher. Two of the naval officers who first used them on board their ships, were Captain Keith Elphinstone, since Admiral Lord Keith, and Captain Henry Trollope, since Sir Henry Trollope, the latter of whom, by means of two carronades or smashers, which he had on board his frigate, beat off several of the enemy's, who were panic struck on seeing the size of some of the shot which he fired into them.

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[*] CHAMBERED.—This word may require explanation. All long pieces of ordnance possess a bore of equal size from mouth to breech; mortars, carronades, and howitzers, however, are chambered, *i. e.*, that part of their bore which contains their powder is narrower than the rest.

[†] The original charge was one-twelfth the weight of the ball, subsequently this quantity was increased to one-ninth, but disadvantageously. The carronade ball is cast exactly the size of the gun's bore, and the only allowance for windage is that

THE MORTAR.—Perhaps this is the most ancient of all fire artillery; although not originally applied to its present purpose of throwing shells. The mortar may be defined to be a short cannon of large bore, chambered, and usually fixed at an angle of 45 deg., adapted for projecting shells, and formerly shot. From the very nature and construction of a mortar, it is evident that whatever mathematical science can be rendered applicable to the practice of artillery, is here most especially requisite. Were we writing a systematic treatise on artillery, a minute description of the parts of a mortar would be, of course, necessary; as, however, we are merely treating in general terms of the force of explosive compounds in urging masses from tubes, all this detail will not be required.

The invention of mortars is commonly ascribed to

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diminution of size effected by the contraction of the ball during cooling.

the Germans, who are said to have employed them for military purposes in 1435, when Naples was besieged by Charles VIII.; but it is not certain whether shells were thrown out of them on this occasion. It seems, however, pretty well ascertained that they were used for this purpose at the siege of Wachtendonk in Guelderland, by the Earl of Mansfield, in 1588; in which year Cyprian Lucas described the mode of charging them.*

At present, the largest description of mortar used in our service is the thirteen-inch; if made larger, they are difficult to transport, and, moreover, it is next to impossible to cast so large a quantity of metal without flaws and other imperfections.

Much variety exists as to the form of the chamber in mortars. The Spanish mortars have spherical chambers; the French, German, and Dutch, conical and cylindrical. The Portuguese, parabolical, and the English generally in the form of a conic frustrum or cylinder.

The Howitzer is a piece of artillery which is chambered, and somewhat short; in these respects resembling a mortar, but, unlike the latter, it may be elevated and depressed. It is a very useful arm, and may be applied to most of the purposes of a cannon or a mortar.

The Petard is an arm never, we believe, used in the present day. It is a kind of very short gun, mounted in a peculiar way, and intended to blow down gates, &c., by being fired with its muzzle close up to them. In former times, various curious devices were employed for preventing this close propinquity between the petard and the gate, one of the most curious of which was a kind of enormous rat gin, set in such a manner as to close on the petard and soldiers applying it.*

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* See his Appendix to the *Quesiti* of Tartaglia.

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* See an engraving of this gin in Hanzelet's *Traités Militaires*, 1598.

ON ARTILLERY PROJECTILES.

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Having said thus much of artillery, it now remains to describe their projectiles. Mere **Cannon-balls** are so simple in their nature and uses that very little comment will be necessary. The reader is probably aware that, in the earlier periods of artillery, cannon-balls were formed, not of iron, but of stone; a material which is still employed by many semicivilized nations.* Fire missiles may be divided into shot and shells; of the former, round shot or balls are the most simple, most commonly used, and their flight is most easily reducible to mathematical calculations. Besides round shot, there are bar shot, chain shot, grape shot, canister shot, spherical case shot, and perhaps some other varieties.

Bar Shot is similar to a dumb-bell, and its effects must be obvious to every one. We need not observe, however, that its flight must be very irregular, and that it is totally unadapted for long ranges; indeed, so questionable are its advantages, that it is now, as well as the variety next to be mentioned, no longer used in our service.

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* In former times other missiles were shot from cannon. Bolts and quarrels were thus used in the reign of Henry V. (1413); these were succeeded by stones. In 1418 Henry ordered the clerk of the works of his ordnance to procure labourers for the making of 7,000 stones for the guns of different sorts, in the quarries of Maidstone, in Kent.—Dr. Meyrick, p. 118; Anderson's *Hist. of Commerce*, vol. vi. p. 351.

The CHAIN SHOT consists of two hemispheres, joined by a piece of chain which fits into the hollow; thus the two halves, when placed in opposition, form one shot, which can be thrust into the gun as such, but which, on emerging, separates into two—the halves diverging to the full extent of the chain. Thus this variety of shot becomes most destructive against a column of troops, or for the purpose of disabling rigging; however, it is now but seldom or never used.

GRAPE SHOT consists of a spindle or spike of metal, around which are tied or quilted several iron shot, of sizes varying acccording to the gun from which they are to be fired. This missile something resembles in general appearance a bunch of grapes—hence its name. Grape shot is most destructive to troops and rigging at short distances—the shots flying asunder immediately the bunch leaves the gun.

The CANISTER SHOT is adapted to the same kind of service as the preceding, but differs from it in form; the balls, instead of being quilted round a spindle, are confined in a canister of iron plate.

SPHERICAL CASE SHOT, or SHRAPNEL SHELLS, as they are more commonly designated, are an important modification of the canister shot; than which they are available at much greater distances. A description of the shrapnel shell would be more intelligible had we previously described the bomb shell, which it very much resembles. It is a hollow sphere of iron, very accurately cast, and just strong enough to withstand the primary impulse of the gun which projects it. Within this shell are balls, about the size of musket-balls, and powder just sufficient, when ignited, to burst the shell. Communicating with this powder is a fuse, which ignites by the flash of the gun, and being calculated to burn a certain time, is intended to communicate its fire to the contained powder, when the missile has reached its destination. Thus constituted, the reader may form some idea of the terrific effects of this missile—combining as it does the long range of round shot with the scattering effect of grape and canister. Some idea, too, may be formed of the difficulties attending the use of this variety; how nicely must the distances be measured by the eye—how well apportioned must be the length of fuse to this distance—how well adjusted the charge of powder, &c. In fact, no variety of missile requires such delicacy of management as the shrapnel shell, but its effects are so terrific as to repay all the trouble employed in bringing it to perfection, and in its continued use.

We now come to the BOMB SHELLS, properly so called, which are understood to be shot out of mortars, but occasionally they have been rolled down inclined planes on an enemy;* and shells of smaller description, but in all other particulars resembling bomb shells, are shot from howitzers and large cannon. The shell, from whatever piece of ordnance it may be shot, is a most destructive weapon, against which the strongest buildings rear their fronts in vain. The idea of the bomb shell is exceedingly simple, although no branch of artillery requires so large an amount of practice and calculation as that which relates to the projection of these missiles. They consist of hollow spheres containing gunpowder, which ignites by means of a fuse, as in the case of the shrapnel shell, on attaining a certain distance. From shrapnel shells, however, they differ in being much larger, thicker, and in containing no balls. They are particularly efficacious in demolishing buildings and blowing up earth mounds, against which mere shot have but little effect—as well as against troops. Instead of being filled with mere gunpowder, they are sometimes charged with a mixture of gunpowder, tallow, and pitch; then they are called carcasses, and are chiefly useful for their burning effects. Carcass shells are, however, not exactly like bomb shells, but are furnished with several orifices through which the fiery mass may leak.

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* The Venetians did this against the Turks at Candia.

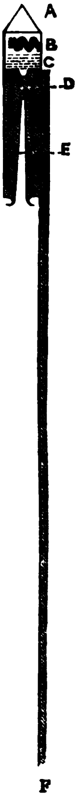
We do not think it necessary to enlarge further on the effects of gunpowder as applied to the projection of missiles from tubes. We have studiously avoided saying anything concerning the distance or range to which such missiles, be they shot or shells, may be cast, thinking it better to make this a consideration of itself.

THE WAR ROCKET.

We now come to the description of another variety of igneous missile, in the construction of which our military artisans stand unrivalled, and which, though not absolutely invented by us, as some imagine, was, nevertheless, brought to perfection by the genius and assiduity of our countryman. The Congreve, or war rocket, being merely a modification of the common pyrotechnic rocket, it is necessary to give the reader a general description of the latter. We will first of all, then, allude to the principles on which a rocket depends for its *propulsive*, or, in reference to the effects of inflamed gunpowder on other missiles, *repulsive* power. All are aware of the mechanical axiom that *action* and *reaction* are equal, no matter what the agent may be. Hence arises the recoil of a gun. Now, it is not difficult to imagine a gun to be charged with a slowly burning gunpowder, so that the recoil shall be continuous instead of instantaneous, in which case the gradually increasing force of the recoil would become a very terrific power—more terrific because, in addition to its penetrating force, it would carry with it a devastating blast of flame, rendering its whole flight visible, and terrifying and burning even where it might not touch. To those who are totally unacquainted with the nature and properties of a rocket, the foregoing general description will afford a tolerable notion; they will begin to think, however, that in order to change a gun so manifestly from its primary use, various modifications will be necessary,—that various contrivances, both chemical and mechanical, must be devised. This is indeed the case; the construction even of a common sky rocket evinces a great amount of ingenuity, and the Congreve rocket is a lasting evidence of the skill of him whose name it bears.

We shall commence with the description of a sky rocket. The case which contains the composition, a slowly burning powder, is usually made of paper rolled hard round a former, and pinched or choked at one end into a narrow opening. This case is next to be charged with composition, in doing which very peculiar management is required, inasmuch as it is found necessary to maintain a hollow cone in the very centre of the composition; the base of the cone corresponding with the vent or small orifice of the case, and the apex extending to within one diameter of its other end; beyond the apex of the cone, the composition is solid. This hollow conoidal form may be effected in one of two ways: it may be made during the formation of the rockets, by means of hollow rammers and a metal spindle; or the rocket may be rammed solid, and the conoidal chamber drilled out subsequently,—in eithr case the result is the same.

We have now described the construction of a rocket in its simplest form, without any appendage; that is to say, we have described the mere propelling agent. Whether it be made to carry with it ornamental fireworks, as in sky rockets, or shot, or shells, or carcasses, as in the Congreve rocket, still the principle remains unaltered. One more important addition, however, is necessary, or else the rocket would have no accuracy of direction, but would fly in a most irregular course; it must be furnished with some means of insuring a moderately direct course of flight. This is accomplished in the common sky rocket, and also in the war rocket of Congreve, by furnishing it with a long stick, to serve as rudder or guide. A diagram, showing a sectional view of a sky rocket and its stick, will explain all that is necessary to the full comprehension of our subject.



A. Paper cone added to the rocket, in order that it may readily cleave the air.

B. Chamber containing ornamental stars and bursting powder.

C. Layer of clay, wood, paper, or some other substance, perforated with a hole through which the fire reaches from the composition, or slowly burning gunpowder, D.

E. Hollow conoidal cavity, for the purpose of effecting rapid combustion.

F. Guiding stick, affixed to the side of the rocket, by means of wire or cord.

To fire a sky rocket, nothing more is necessary than to apply a light to the orifice or vent, when the composition immediately inflames, and fire rushing out with great violence, the rocket proceeds in the direction to which its apex is pointed.

Whatever doubt there may be as to the antiquity of guns, there is none as to the antiquity of rockets, which have been known in China and India from time immemorial, and indeed used in those countries for warlike purposes. There might formerly have been seen, at the Adelaide Gallery, a Chinese war rocket, differing in nothing from the sky rocket we have just described, except that a barb is affixed to the foremost extremity of the stick, which was made to project to the rocket's very extremity.*

Although the common sky rocket has very considerable penetrating force, and although, as we have seen, it has long been used as a warlike missile in Eastern countries, yet all who have witnessed the firing of a sky rocket must at once recognise imperfections that would render it ill adapted to warfare between more civilised nations, who find it necessary to study the laws which regulate the flight of projectiles, and reduce the firing of them to some system. It is difficult to make two sky rockets exactly of the same weight; to fill them with exactly the same quantity of composition, rammed of the same hardness, and to supply them with guide sticks exactly corresponding in every particular; yet, without some close approximation in these respects, the flight of such rockets would never be prognosticated with anything approaching to accuracy.

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* Directions for making and using rockets may be found in the following old works:—Robert Anderson, On the making of Rockets; Biringucci Vanuccio, *De la Pirotechnia*, 1540; Bate, John, Mysteries of Nature and Art, 1654; J. Hanzelet, *Traités Militaires*, 1598. In this book is represented a method of employing the rocket in war, thus anticipating in Europe Congreve in the employment of this arm.—NYE, NATH., *Treatise on Fireworks.*

The first person in this country to whom the idea of using rockets as warlike agents seems to have suggested itself, was General Desaguliers, but all his experiments were failures, and eventually he abandoned the idea. Such an infelicitous termination of the inquiry, however, did not prevent Sir William Congreve from being sanguine of success; he forthwith commenced a series of experiments on common rockets, procured from various makers; and on others, constructed according to the Woolwich laboratory rules. He found, in the first place, that the range of these rockets was inconsiderable in a military point of view; and secondly, that they were devoid of all necessary accordance amongst each other—evils which he applied himself to remedy. His first material employed for making the cases was paper, but eventually he bethought himself of sheet-iron, a substance which, possessing greater weight or mass than paper, contributed much to extend the range of a rocket. Sir W. Congreve, amongst other modifications, diminished considerably the length of rocket sticks, thus rendering the whole missile much more portable, and subject to less deflection than in its original state. The sticks, at this period, in the history of Congreve rockets, were still lateral, or appended to the sides, as in the common pyrotechnic rocket—an arrangement which the slightest reflection will show must have considerably interfered with accuracy of flight, besides presenting many other minor objections: for instance, this arrangement did not admit of the stick being expeditiously fixed, neither could the rocket be shot conveniently through a tube. It was easier, however, to recognise the disadvantages attending this arrangement of the guide stick than to offer a remedy. Congreve, nevertheless, overcame this difficulty, and succeeded in devising a plan for attaching the stick centrally, thus giving the whole rocket the straightness of an arrow, and consequently increasing the accuracy of its flight; although much yet remains to be done in this respect, even in the present improved form of the weapon.

Having already given the reader a diagram of the common sky rocket, we may simply observe that the first war rockets were precisely similar, only their cases were of iron instead of paper, and instead of being headed with ornamental stars, they had appended to them balls, shells, carcasses, &c., according to the use for which they were intended. The construction of the war rocket, as at present modified, will be rendered intelligible by the subjoined diagram.*

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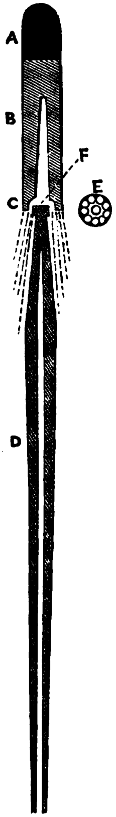
* The stick is represented somewhat short, for the sake of convenience. The actual length of the 6 lb. rocket stick is *seven feet*, of the 12 lb. rocket stick, *nine feet*.



The part A indicates the piece of iron attached to the end of the rocket, and serving as a shot—it might have been a shell, a carcass, &c. B corresponds with the body of the rocket, filled with composition, and perforated as in a common rocket; the base of this conical opening expands, it will be observed, into a chamber, F, which is absolutely necessary in order to prevent the rocket bursting; although this necessity adds greatly to the mechanical difficulties which must be encountered. C represents a sectional view of a piece of gun-metal, a front view of which is shown by E. In this piece consists the great peculiarity of the Congreve rocket, enabling the stick, or rather the iron with which it is shod, to be screwed into the central opening, whilst the smaller peripheral orifices communicating with the hollow cone, of which the section of two only are seen in the diagram of the rocket, serve as vents to the flame, and correspond with the one central opening in the common sky rocket.

Such is an outline of this terrible weapon, once peculiar to ourselves amongst European nations, but now employed almost universally. Of course, the details of their construction are very properly kept secret, therefore we can give no more than a general description of their manufacture; they are not, however, difficult to prepare, as we have convinced ourselves by trial, although it is difficult to make two which exactly correspond in every particular. It is imagined by some that the proportion of the ingredients is a great secret; this, however, is a fallacy; knowing the object desired to be gained, the composition naturally suggests itself. Now, the object is to compound of three ingredients—nitre, sulphur, and charcoal—a mixture of the greatest power short of bursting the case: chemical science and a few trials soon lead to the desired end.

The manufacture of rockets as military weapons must always remain, notwithstanding its simplicity in theory, a matter in practice of very considerable difficulty. When we consider that the expansion and contraction of the iron cases render the composition liable to crack; when we reflect on the difficulty of preventing contact between the iron and the composition for any long period,* and of thus guarding against oxidation; or the difficulty in making every rocket of the same size, and to contain its due weight of composition; of ramming them equally hard; and of supplying them with sticks correctly planed,—these difficulties would almost bring one to the conclusion that rockets must remain mere elegant pyrotechnical devices; or if used in warfare, not to be reckoned amongst the appliances of the well-trained and precise artillery of Europe. The superior dexterity of our artizans, however, has in great measure overcome these difficulties, and the rocket, although confessedly an erratic missile, is, when not pressed beyond its proper sphere, a most efficient and terrible weapon.

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* We believe the interior of a war rocket case is lined with paper glued to the iron, to prevent the composition touching the metal, and thus rusting it; a result which would entirely spoil the missile.

Like most inventors, Sir William Congreve imagined that his war rocket would completely alter the practice of artillery, and would be all but universally applicable, whether for the purpose of battering fortifications or slaughtering men. He advocated the plan of furnishing rockets to every part of the army—cavalry, infantry, and artillery—and was opposed to the scheme of organizing an independent body of troops, like the present rocket troop, for the employment of this weapon. The peculiar advantages of the rocket, as pointed out by Congreve, are, 1. magnitude unlimited; 2. portability; 3. freedom from recoil; 4. rapidity of discharge; 5. devastating and terrifying effects of fire in addition to its propulsive force.

Several circumstances conspire to restrain the size of common ordnance within certain limits: there is a difficulty in casting large guns; when cast, there is a difficulty in transporting them;* and their missiles, be they balls or shells, are so unwieldy as materially to interfere with their ready use. According to the testimony of Congreve, however, it is difficult to imagine the limit to the practicable magnitude of a rocket. The largest used in our service, we believe, weigh no less than *three hundred pounds!* and are about ten feet high; their extremity being furnished with either a shell or a carcass. Congreve did not think it would be difficult to construct rockets of a much larger size than this; but we are not aware whether he ever carried his idea into practice.

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* The weight of a 12-pounder gun is 18 cwt., while that of a 12-pounder rocket tube, which projects the *same weight of ammunition*, and *at least* to the same distance, *is only* 20 *lbs.!*—CONGREVE, *Op. cit.*, p. 37.

In field operations the rockets most usually employed are much smaller than the variety of which we have been speaking, the usual sizes being six, twelve, and eighteen pounders.

The rocket, urged as it is by its own impulse, and therefore requiring no ordnance to project it, has the advantage of great portability. Even a cannon no larger than necessary to project a six-pound ball, weighs several hundred pounds, and, therefore, is found difficult to be transported into mountainous regions. Six-pound rockets, however—indeed rockets of much heavier weight—may be transported everywhere. If, then, the flight of rockets could be rendered as accurate as the flight of shot, the trouble and expense of conveying cannon to mountainous regions might be dispensed with.

The next great advantage of the rocket to be spoken of, is its freedom from recoil, which frequently becomes a serious impediment to the employment of common artillery. In most engagements, whether by land or sea, so great is the obscurity occasioned by smoke, that after the cannon have been pointed and discharged, the second round is fired more or less at random—their recoil having disturbed the original aim, and the object being no longer visible. Now, a rocket has no recoil; therefore, all circumstances being the same, a second rocket will follow the path of the first. Great as this advantage may seem at first, in practice it is entitled to very little consideration, on account of the natural irregularity of the flight of these missiles. There is another case, however, in which the absence of recoil in a rocket renders it a most valuable kind of artillery. It was formerly thought impossible to use mortars at sea, on account of the strain which they occasion by their recoil. This difficulty has long been overcome; ships having been made of a peculiar construction, purposely adapted for the service, so strongly built that the shock does not materially affect them until after considerable firing. It would be quite impossible, however, to use mortars in a boat, or even in a vessel not constructed on purpose; an objection which does not apply to the rocket, which, although of the largest size, may be shot without difficulty from boats just large enough to carry them.

Rapidity of discharge, and concentration of fire, are other advantages possessed by the rocket—requiring merely to be placed in the intended direction, and ignited. Batteries of several hundred rockets may be planted against the enemy, and fired almost at the same instant by the aid of quick match. The particular methods of firing rockets in volleys will be mentioned presently.

The last specific advantage of the rocket which remains for us to mention, is the devastating effect of its fiery train. Cannon-balls and shells rush on their objects unseen, or faintly visible; not so the rocket, which carries with it a long fiery tail, burning everything in its course, exploding ammunition waggons, mowing down troops, and producing amongst cavalry the most inextricable confusion. No horse, however well disciplined in regard to other artillery, will stand the hissing of a rocket, not even the horses of the rocket brigade.

If the rocket could be endowed with the precision of which cannon are susceptible, it would indeed accomplish all that Congreve hoped; but such precision has not yet been attained, and this for obvious reasons. In the first place, the theoretical determination of a rocket's flight is a much more difficult affair than the determination of the flight of a shot or shell; because in the former case we have a constantly diminishing weight (occasioned by the burning of the composition), producing a continued variation of the centre of gravity; whereas in the latter case the weight never varies, and its centre of gravity never shifts. So great is the care, however, with which our rockets are manufactured, that we might be warranted in entertaining the idea that the difficulty just alluded to might be overcome by the results of practice: unfortunately, however, there is a much more serious cause of error in the deflecting agency of currents of air. If such currents are capable of producing a manifest effect on the flight of shot and shells, bodies either homogeneous, or nearly so, how much greater must be this influence on a missile formed like the rocket, which, in addition to its being composed of two separate materials, wood and iron, departs as far as possible from the spherical or most perfect form,* in regard to freedom from the interfering causes of atmospheric currents! Congreve considerably diminished the length of stick, and in this he accomplished much; he also endeavoured to dispense with the stick altogether, and attach in place of it a ball of iron. The plan, however, did not succeed, neither have many others, attempted at various subsequent periods. Probably, also, the desideratum of enabling a rocket to be employed without a stick has been now accomplished by Mr. Hale, concerning whose rocket we shall have to speak hereafter. We have called this deviation from the visual course an imperfection, and, doubtless, it materially diminishes the sphere of applicability of the rocket. If, however, this arm be employed for its true and legitimate purposes—that is to say, against large bodies of troops, or large masses of buildings, or shipping, then this same erratic course becomes a perfection.

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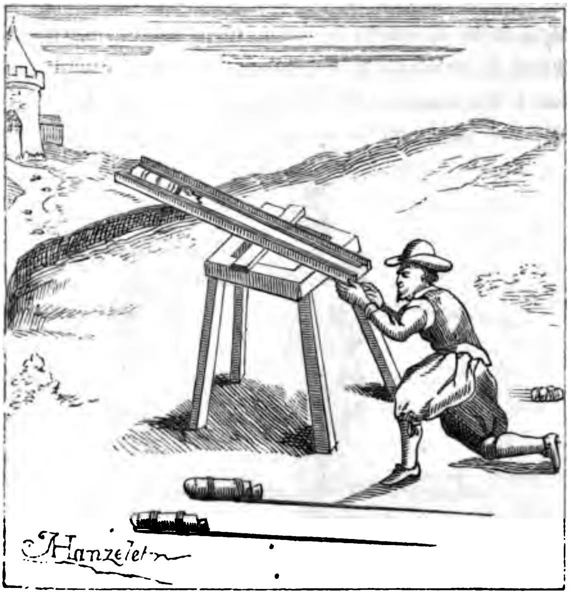
* We here limit our observations to all projectiles which are shot from non-rifled guns, or which, like the Congreve rocket, during their flight do not assume the rotatory or rifle motion.

There are many cases in which shot and shells can be guarded against, owing to a knowledge of their general accuracy of projection. This cannot be said of the rocket, against which all common precaution is in vain; once amongst a body of troops—once its original course departed from, and no one can tell whither it will go. It may seem to fly to the right, the troops give way to let it pass, and thicken on either side; on a sudden the missile encounters some impediment,—a stone, a little mound, a dead soldier,—and forthwith its course is changed towards the left; hissing, plunging, darting like a meteor of fire, it rushes into the thickest ranks—what it fails to strike it burns; its force now seems expended—already it has penetrated through a dense mass of living beings,—for an instant it lingers: its fiery elements, now gaining new strength, urge it again forward with a renewed and terrible force! This is, indeed, a fearful peculiarity of the rocket: other projectiles being once impeded in their flight, cannot renew their power; theirs is merely a first impulse—the primary force of gunpowder: not so the rocket, which carries with it its own propelling agent, and thus literally *vires acquirit eundo.*

It now remains for us to describe the apparatus which is employed for the purpose of directing rockets in their proper course. When first they were introduced into the army, Sir William Congreve employed either grooved channels or tubes. The former idea might have originally suggested itself to him, but it is certain he had been anticipated by Hanzelet, who, at page 38 of his *Traités Militaires*, published in 1598, gives a description and diagram of the military use of the rocket. The latter we subjoin.*



In the present day, when any apparatus is employed, this is invariably of the tubular kind, but not unfrequently rockets are simply laid upon the ground connected by means of quickmatch, and fired in what is called *the ground volley.* The present improved rocket tube is shown by the annexed diagram, which requires no minute description. It will be seen to be capable of elevation and depression by a contrivance which is obvious; any necessary angle of elevation is taken by means of a graduated slide, which is seen attached to the upper part of the tube.

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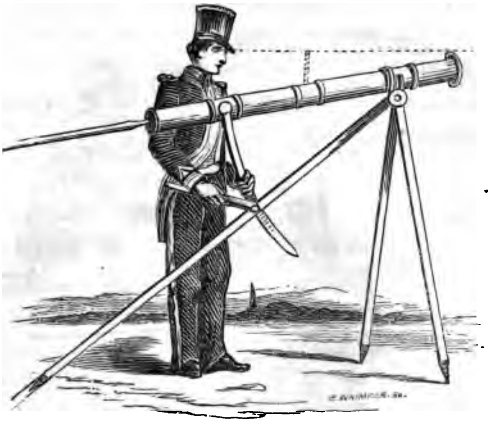
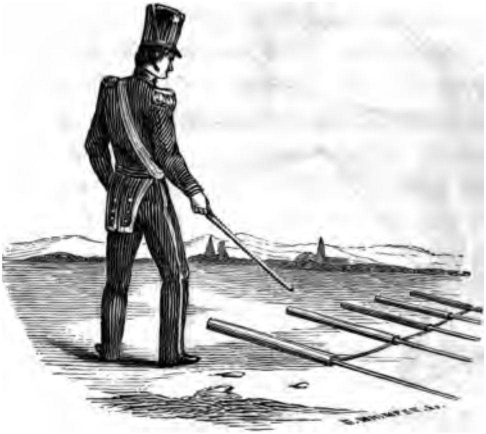
* The chapter is thus headed:—*Comme l'on peut tirer droittement une fusee à fleur d'orizon ou autrement.* Then follow a description and woodcut. The rocket is directed by means of a groove. The very extraordinary perspective of this sketch, we beg leave to say, is M. Hanzelet's own—not ours.



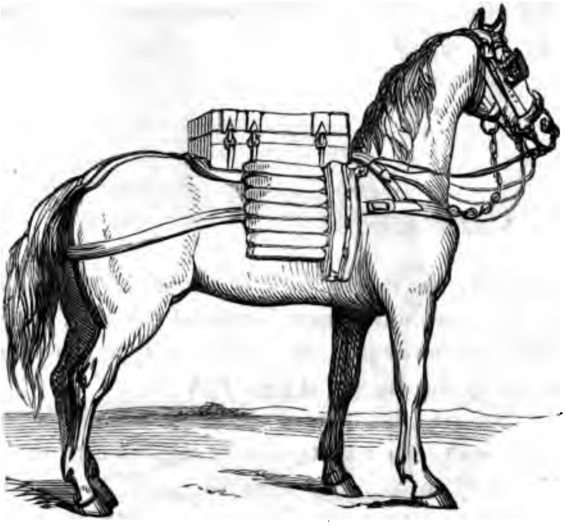
Sir W. Congreve invented carriages, on each of which was mounted many such tubes. These carriages were intended to run into action like light field guns, yet pouring a discharge of metal from each tube equal to the effect of the gun as regards penetrating force, in addition to the devastating effect of fire. These carriages, however, are now no longer employed; when rockets are required to be fired in great numbers simultaneously, the ground volley, as it is called, is found to answer every purpose.

This arrangement consists in laying any number of rockets on the ground at determinate distances from each other, connecting them by a quick match, and firing them in rapid succession, for which purpose only the end of the match requires to be ignited. If the ground be moderately smooth, the rockets proceed, for the first 100 or 150 yards, near the ground surface; afterwards, however, they rise more or less, become deflected, and rush about in a most destructive manner. The manner of firing the ground volley is illustrated by the accompanying diagram.

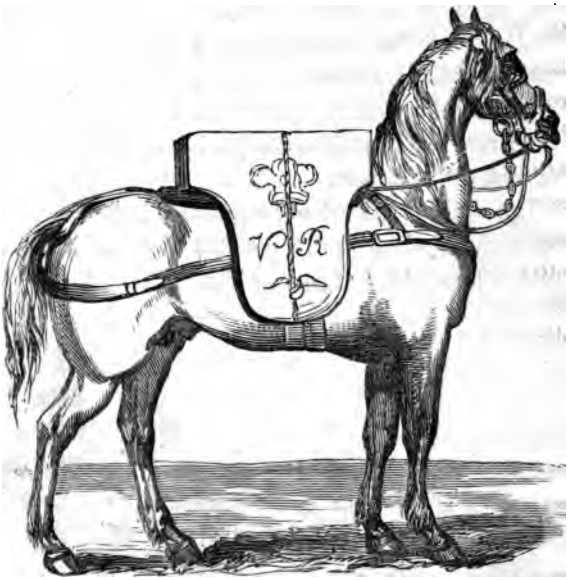


Sir W. Congreve, as we have already observed, considered that the peculiar genius of the rocket lay in the facility of its general adoption by all troops; he was averse to the formation of a specific rocket troop, and particularly advocated the employment of the arm by cavalry, which he maintained might thus derive the power and force of artillery without its weight and difficulty of transport.

Annexed is a sketch of his proposed plan of carrying the rockets, which are represented to be arranged on each side of a kind of pack-saddle. The sticks, in two lengths, being carried in a box on the horse's back; when used they were to be joined by a screw.



This scheme of Congreve's has not been thought



available; the rockets are now carried in wagons on purpose, and on the wagon is buckled the tube, which when used is removed and fixed on its tripod, as represented by the diagram at page 129.

Each man, however, of the rocket troop rides into action with some rockets already supplied with sticks, and ready to be fired; these he carries in buckets, attached on either side to his stirrup. Of six-pound rockets three are thus carried on either side, after the manner of a lance, and thus they are immediately available before the rocket wagon can be opened.

Such was the amount of development received by the rocket as a military weapon from the labours of Sir William Congreve; and although his ideas of their large sphere of application have been far from realized, rockets on his construction have always, since their introduction, constituted an important part of British artillery resources. The presence of the stick, however, continued a serious drawback to their general applicability, and numerous investigators directed their attention to the discovery of some means of abolishing the incumbrance. It was foreseen by all who had directed their attention to this subject, that if the stick of a rocket were ever abolished, the only available means of insuring accuracy of flight would consist in imparting to the rocket itself a rotatory or rifled motion. Now, theory only furnishes us with two classes of suggestions for accomplishing this in any projectile, either by shooting it from a rifled gun, or supplying it with some eause of rotatory force within itself. The latter is the only idea apparently eligible as regards the rocket, which is not shot from a gun, but the course of which is dependent on its own recoil. All the earlier attempts to impart a rifled motion to rockets were based upon the idea of wings or vanes, attached to the rocket itself; or the idea of spiral grooves cut in the external portion of the rocket's case, against which grooves the atmosphere, exerting its pressure during the projectile's flight, should impart the necessary spiral motion. These attempts, however, all resulted in failure.

Within the last few years Mr. Hale has succeeded in accomplishing the flight of a rocket without the stick, by some means not yet made public. But his rockets may be plainly seen during their flight to assume the rifle motion, and this is probably secured by giving a peculiar direction to the escaping blast. We have never been fortunate enough to witness practice with the rockets in question, but we have taken care to assure ourselves by sufficient evidence that they are at least equal in power and range to the rockets of Congreve, whilst the absence of the stick confers on them a very great advantage over the rockets of Congreve, both as regards portability and accuracy of flight.

Mr. Hale has introduced another improvement in the manufacture of rockets, besides the one of which we have spoken. Instead of impacting the composition by means of ramming, this gentleman avails himself of the more equable and still more powerful force of the hydrostatic press. In the firing of his rockets, also, Mr. Hale has brought into requisition a new principle, by confining them in their tube, or on their rest, until they have acquired a certain predetermined initial force. Thus, for a ten-pound rocket, the inventor uses a repressive force of, we believe, six pounds, until the rocket can overcome which, it is not allowed to commence its flight. The advantage of this contrivance will be evident on referring to the conditions under which an ordinary Congreve rocket commences its flight, and the consequences therefrom resulting. No sooner has it generated sufficient power to overcome the inertia of its own mass, and the further restraint of friction against the tube, than it at once rushes forth in the air; but in consequence of a deficiency of initial velocity it droops on first emerging from the troop, and thus loses its accuracy of flight. Mr. Hale's restraining device obviates this disadvantage, and tends to impart to the rocket a correct line of flight.

Mr. Hale's rocket system has been narrowly investigated by a military committee of the Swiss confederation, also by a similar committee appointed by the American Government; the result of investigation in either case having resulted in their approval and adoption. The secret of their manufacture has also, it is said, been communicated both to the French and the Russian Governments.

It may not be devoid of interest to present the reader with the reports, as regards the powers of Mr. Hale's rockets, published by the Swiss and American Governments:—

"The federative Government of Switzerland caused extensive experiments of the power and advantages of this weapon to be made, under the superintendence of a committee of artillery officers, and a number of rockets were fired from a stand at 5, 10, 15, 25, and 27 degrees of elevation. A target was placed at 1,200 paces, and the rockets used on this occasion were 10-pounders, the smallest of Mr. Hale's invention, his largest being 100-pounders. One fired at 5 degrees went on like a serpent, and never rose above 6 feet from the ground. Another, at 10 degrees, made its first graze at 500, the second at 1,300, the third at 1,900 paces, and without rising more than 9 feet from the ground during its flight. One discharged at 15 degrees first struck the ground at 1,200 paces, the second time at 2,200 paces, and when rising again the shell exploded; its greatest lateral deviation was about 50 paces.* A single 10-pounder rocket was fired at Woolwich by Mr. Hale, in the presence of some of his friends, on the 30th of March, 1849. A wrought-iron tube, moving on a cast-iron stand, was used on this occasion, and the rocket, being discharged at an angle of 20 degrees, without previously grazing, penetrated 10½ feet into wet, close, loamy soil, at the distance of 5,200 feet, which is scarcely less than the effect of a 12-pounder shot at the same distance.

"It is understood that the Government of the United States, after testing the efficiency of Hale's rockets by a series of experiments made under the direction of a committee of artillery officers, purchased the secret, and used this instrument with the greatest advantage during the late Mexican war. The following are the official American documents regarding Hale's rockets:—

"'*Washington, December* 1, 1846.

"'REPORT of the joint Board of Officers of the Army and Navy, appointed by the Secretaries of the War and Navy Departments, for examining Hale's rockets.

"'The Board have tried by firing on land and water 2¾-inch rockets, presented to them for that purpose by Mr. Hyde, by whom they were procured from the inventor, Mr. Hale.

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* See the Army and Navy Register, March 1, 1849.

"'From these trials the Board have arrived at the following conclusions:—

"'1. The effect of the rockets, with regard to range, force, and accuracy, is at least equal, and probably superior, to that of the ordinary Congreve rocket of the same size.

"'2. The fact of this rocket being without a stick gives it an incontestible superiority over the Congreve rocket, with respect to facility, convenience of service, and, especially, for use on board of armed vessels or boats.

"'3. It is therefore recommended that an arrangement be made with the proprietor for the purchase of the full instructions requisite for making these rockets.

"'4. The evidence of such information being fully and correctly communicated should be the making, under these instructions, of a certain number of these rockets, of at least two sizes (say ten each of 2-inch and 3-inch), which shall perform as well as those exhibited to the Board.

"'*Officers of the Army.*

"'(Signed) JOSEPH G. TOTTEN, *Colonel and Chief Engineer.*
G. TALCOTT, *Lieutenant-Colonel of Ordnance.*
A. MORDECAI, *Captain of Ordnance.*

"'*Officers of the Navy.*

L. WARRINGTON, *Commodore.*
THOMAS A. P. C. JONES, *Captain.*
L. M. POWELL, *Commandant.*
A. B. FAIRFAX, *Lieutenant.*
Honourable JOHN Y. MASON,
Secretary of the Navy.'

"'*City of Washington, December* 9, 1846.

"'SIR,—The joint Board of Army and Navy Officers, appointed by us to examine Hale's rockets, have made a confidential report, of which a copy is enclosed. We are authorised by the President of the United States to submit, for your acceptance, the proposition recommended by the Board in the Report.

"'Will you be pleased to make known to us your determination. No delay which can be avoided will occur, if you accede to the proposition in applying the proposed tests, and your communication in writing of the necessary instructions will be treated as confidential.

"'Respectfully,
"'Your obedient Servants,
"'(Signed) W. L. Macey, *Secretary at War.*
J. Y. Mason, *Secretary of the Navy.*

"'Mr. J. B. Hyde,
Now at Washington.'

"'Report of the trial of Rockets of Hale's patent, made at Washington Arsenal, January 5, 1847.

"'These rockets, presented for trial in pursuance of the former recommendation of the Board, were made at Washington Arsenal, under the direction of Mr. Hyde.

"'There were fifteen 3-inch rockets, two of them with shells in the head, and thirteen 2-inch rockets, four of them with shells; of these, the following were fired in the presence of the Board:—

"'Six 2-inch, with shot-heads.
Three ditto, with shells.
Four 3-inch, with shot-heads.
Two ditto, with shells.
"'At various elevations from 14 deg. to 35 deg.

"'The accuracy of direction and the ranges were, in all respects, satisfactory, and the Board are of opinion that these rockets were quite equal to those before exhibited to them by Mr. Hyde, as having been made by Hale, the inventor; and that Mr. Hyde has, therefore, "fully and correctly communicated the necessary instruction for making Hale's rockets."

The trial of the rockets was witnessed by the members of the Board, whose names are signed to this report.

"' *Officer of the Army.*
"'(Signed) A. MORDECAI, *Captain of Ordnance.*

"' *Officers of the Navy.*
L. WARRINGTON, for himself,
and T. A. P. C. JONES.
L. M. POWELL, *Commander.*
J. B. FAIRFAX, *Lieutenant.*
"' *Washington, January* 6, 1847.'

"'AMONGST the documents printed for the use of the Senate of the United States of America, by a resolution of the 7th December, 1847, is the following short report by Captain A. Mordecai, commanding the Washington Arsenal:—

"'MR. HALE'S ROCKETS.

"'In the month of December last, a war rocket, of a new kind, invented by Mr. Hale, of England, was offered to the notice of our Government, and a mixed Board of officers of the army and navy was appointed to test the invention.

"'Experiments were accordingly made with some of Mr. Hale's own rockets, and with others made at the Arsenal according to his specification; the results of these trials were so satisfactory, that, on the recommendation of the Board, the right of using the invention was purchased by the Government.

"'The peculiar advantage of this new projectile is that of having its directive force in the body of the rocket, thus dispensing with the use of the cumbrous stick attached to the Congreve rocket. About 2,000 of these rockets, of the calibres of 2¼-inch and 3¼-inch, have been made at this Arsenal, and the trials which have taken place, from time to time, seem to confirm the favourable opinion at first formed, that, in extent of range and accuracy of direction, they are equal, and perhaps superior, to the common rockets of equal size. A report of the trial of those which have been sent into the field is looked for with interest.'"

We shall conclude this account of rockets by enumerating some of the results which they have brought about on different occasions of their being used.

The first employment of rockets in European warfare was in the attack of Boulogne, October 8, 1806. "In about half an hour," says Congreve,[*] "about two hundred rockets were discharged; the dismay and astonishment of the enemy were complete—not a shot was returned—and in less than ten minutes after the first discharge, the town was discovered to be on fire." It has never been correctly ascertained how much of the town was consumed on this occasion, the French having given but vague representations of the calamity. The fire, however, could not have been inconsiderable, since it raged from two o'clock in the morning to the next evening; and a further proof to this effect is the caution with which Lord Lauderdale and his suite were guided through the town some few days after the attack, not one of them having been suffered to leave the inn at which they were placed, nor any one permitted to have communication with them; even in passing through the streets, they were conveyed in close cabriolets.

In 1807 rockets were again used with great effect in the attack on Copenhagen. Subsequently to this period a rocket troop was formed at Woolwich, under Captain Bogue. At the memorable battle of Leipsic this rocket troop afforded the first proof of the military utility of their terrific weapons. They were the only English present on the occasion, and on firing a volley against a mass of French infantry, the latter, terrified at the devastation and slaughter effected by the new weapon, at once threw down their arms.

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[*] A Treatise on the General Principles, &c., of the Congreve Rocket System.

Such are a few of the memorable occasions on which rockets have been employed in actual warfare. Did our limits permit us to trace the progress of our arms in India, we might still further illustrate their tried efficacy. Enough has been said, however, to demonstrate their advantages and disadvantages; those who require further description of this weapon, and its application, we must refer to Congreve's interesting book, which we have alluded to more than once.

ON THE APPLICATION OF GUNPOWDER TO MILITARY MINING.

Our remarks on this subject will be very few, inasmuch as the mere principles of mining operations, so far as relates to the operation of gunpowder, are simple enough, although the application of these principles to practice demands a great amount of mechanical, mathematical, and chemical skill. Modern engineers, particularly the French, have devoted especial attention to this subject, and have calculated the effects of gunpowder, at various depths and in various soils, with great accuracy. In England, the gunpowder for mining operations does not differ in composition from powders used for other services; its immediate force or rapidity of fire, however, might be diminished with much advantage. We have already observed, that a powder may ignite so rapidly that its power as a propulsive agent is materially injured, because a certain amount of continuity of action is desirable; the remark applies still more forcibly to the case now under consideration, and hence the fact, so well known to our mining communities, that damp powder is more efficacious in blasting rocks than dry powder.

It is not our province to detail the operations of military mining; probably the only interesting part of the subject to general readers is the plan of communicating the fire to the magazine. This was effected by means of gigantic quick-matches or leaders, made of long canvas bags, containing powder; now, however, military science has availed itself of the voltaic battery for this purpose. The use of this instrument is attended with many advantages where it can be employed. The magazine, no matter how far situate from the operator, is fired instantaneously; the communicating agents, being merely wires, are more easily laid down than the canvas hose employed in the old operation. These are two great advantages, and the voltaic battery is by no means difficult to manage. It may not be unnecessary to state by what means the voltaic influence is applied to this purpose; the explanation is simply this: if the electric circuit be completed by a conductor of metal sufficiently small, the latter becomes hot: provided its size be sufficiently diminutive, it becomes red or white hot;—particularly if the metallic communication be effected by platinum, which is a very bad conductor of heat, and therefore rapidly assumes a very elevated temperature. Supposing, then, it is desired to fire a magazine by voltaism, all that is necessary is to transfix a cartridge with a piece of platinum wire, each end of which is joined to a larger wire of copper, and the latter, on either side, is placed ready to communicate with the poles, or, as they are now called, the *anode* and *cathode* of a voltaic battery. This communication may be effected in an instant at word of command, when immediately the platinum wire becomes red hot, and the cartridge and whole magazine explode, blowing a large crater out of the earth, and hurling into destruction such works or troops as may be on the surface.

The application of voltaic electricity has, perhaps, been of still greater use in exploding subaqueous magazines—operations which, before its introduction, were accomplished by far more inconvenient methods.

THE HISTORY AND EMPLOYMENT OF SMALL FIRE-ARMS.

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LONG after cannon, mortars, and other ordnance of fire had supplanted the more ancient balista, catapult, battering ram, and other mechanical engines of war, the long bow, arbalest, and sling, maintained their undisputed sway. The reason of this is not difficult to assign; the construction of small arms, to be more effective than our own national weapon, *the long bow*, or the arbalest of continental Europe, was a matter of no small difficulty. The mechanical ordnance of ancient times was either ineffective, or its power was achieved at the expense of vast mechanical skill, and expenditure of material; its transport was always extremely difficult, even for the purpose of siege, or garrison service; in the field, this difficulty rendered its employment almost unknown. Our ancestors, however, were much better supplied with small missiles: we have already spoken at some length of the force of the bow; we have individualized instances of its power and convenience,—we have seen that it was in the powerful hands of our old archers a most prompt and effective missile; the reader will still better learn to appreciate its valuable qualities, when he shall have directed his notice to the imperfect small fire-arms of our fathers. In proportion as the manufacture of small fire-arms improved, the advantages derivable from this kind of missile could not fail to be in some degree appreciated. Prejudice, nevertheless, amongst other causes, strongly operated against the general application of small fire-arms. Indeed the prejudice against even *cannon* was at first very strong: the iron clad knights had long managed to guard their own bodies against mechanical missiles; a good suit of armour would generally repel the blow of an arrow, and the horses, less fortunate, having grown mad with rage and pain from the thrusts of barbed missiles, and thrown their riders, the doughty warriors would roll on the earth awhile, and then retire with a few insignificant bruises—to engage in this innocent tilting another day.* The introduction of cannon was a sad blow to their chivalry: loudly did they protest against the villanous saltpetre; loudly they inveighed against such unknightly modes of fight; the force of public opinion was, however, too strong for their prejudices—the opinion had become prevalent that warfare, consistently with its true genius, could not be rendered a gentle pursuit. Then many of those belted knights, finding that warfare had become so rough a pastime, quietly seceded from the ranks, and betook themselves to arts more worthy of their blood; others grew accustomed to the cannon and risked their chance of death. But when the ungentle musket began to supplant the bow, what a terrible innovation was there:—deep and loud were the execrations of the knights; low the mutterings of the armourers, who began in near prospective to see their occupation gone. For a period the strength of armour was increased: breastplates acquired the thickness of anvils; helmets became like iron cooking pots; horses tottered under their heavy loads—knights were not infrequently smothered in the fray! It was useless any longer to affect disgust at innovations; the day of chivalry had passed; knights felt they were no longer the strength of an army, nor did their armour secure them any immunity from injury and death. Gradually, then, manual weapons of fire were universally employed; the soldier threw away his armour, the knight relinquished his lance; rapid evolutions succeeded to the slow but ponderous charge, and the whole system of war changed.

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* In several battles about this time not a single knight was slain: when unhorsed it was difficult to penetrate the joints of their armour by the *misericorde* or dagger, and at the battle of Fournouë under Charles VIII., a number of Italian knights having been unhorsed, could only be killed after they had been broken up like so many lobsters with woodcutters' axes! This circumstance justifies the remark of James I., that defensive armour was a double protection,—preventing the bearer at the same time from being injured, and from injuring others.

VARIETIES OF SMALL ARMS INDIVIDUALLY CONSIDERED.

Doubtless, the cannon soon after its discovery was occasionally reduced in size, so as to render it adapted for particular purposes; at length, after passing through many metamorphoses and gradations of diminution, it became a mere manual weapon of fire. It is impossible to say, then, when or where such small fire-arms were invented, but we pretty nearly know the period of their introduction to various European armies. "They appear to have been thus introduced into the English army in 1471, when Edward the Fourth, landing at Ravenspur, in Yorkshire, brought with him, among other forces, 300 Flemings, armed with hand-guns. This is fifty years before the date usually assigned for their introduction; Mr. Anderson and other writers placing that event at the siege of Berwick in 1521, soon after which they were generally adopted in England."*

In 1555 the Spaniards, under Philip the Second, are said to have employed small fire-arms, but they were of a very unwieldy description. It had also always been considered difficult to protect archers against a resolute charge of cavalry, and the difficulty was greatly increased in the case of musketeers. The weapons and ammunition of an archer were light, his arrows flew in quick succession, and he was subject to no other cause of failure than the breaking of his bow or string.* Far different was it with the musketeer; his weapon was most unwieldy, exceedingly tiresome to charge and discharge, and subject continually to the chance of missing fire. Having fired their weapons, a host of musketeers were rendered for a time defenceless, and cavalry might pour down and put them to the rout; this was a sad disadvantage under which the musketeer laboured, and to overcome which various means were devised, the most common of which consisted in making the rest an arm of defence, appending to it a concealed dagger, which flew out on touching a spring, or affixing a spike to the head. Rests thus armed were called the Swedish or swine's feathers.†

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* Wilkinson on Engines of War. See also Anderson's History of Commerce, vol. i. p. 351; Leland's *Collectanea*, vol. i. p. 721; Grose's History of the English Army, vol. i. p. 160.

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* Hence it was not unusual to have two strings to the bow; and hence our common proverb. See Ascham's Toxophilus.

† Grose, vol. i. p. 165, De Limière's History of Louis XIV., vol. vi. p. 88; Strutt's Manners and Customs, vol. viii. p. 91; *Turner's Pallas Armata*, p. 176.

For a comparison of the several merits of archery and fire-arms, consult Humfrey Barwick's Discourse concerning the Force and Effect of all Manual Weapons of Fire; Smythe (Sir John, Knt.), Concerning the Force and Effect of Weapons. Lond. 1590; Sir Roger Williams's Brief Discourse of Warre. Lond. 1590; and the various treatises on archery already referred to.

The greatest change which fire-arms have undergone relates to the method of discharging them. At first they had no lock whatever, but were discharged by the manual application of a match; then followed the matchlock, afterwards the wheel or pyrites lock, next the flintlock, and, lastly, the percussion lock, under one of its many various forms; this seems to be the extreme limit of perfection, leaving nothing more to desire.

The MATCHLOCK was a very obvious and simple contrivance for dashing the lighted end of a piece of rope, soaked in nitre, upon gunpowder contained in a little pan communicating with the charge. This means of firing guns was, on the whole, very efficacious, and is still employed in most Eastern nations. The match, however, is liable to be extinguished by rain, and is very dangerous to be carried in such close proximity with gunpowder as it necessarily must. The ancient European musketeers used generally to carry their lighted match in a little iron cylinder perforated with holes, but in rainy weather they carried it in their hats.

The PYRITES, or wheel-lock, seems to have been introduced into England about the reign of Henry the Eighth. It continued in use until the time of Charles the Second, when the flint-lock became general. This wheel-lock, now obsolete, but once universal in European armies, it may not be amiss to describe. The original idea of the contrivance may be recognised in an old *büchse* at Dresden, which has a piece of pyrites fixed opposite the touch-hole, which is intended to be rubbed with a file for the purpose of eliciting sparks to ignite the powder. In its improved form it consists of a small grooved steel wheel, to the axis of which a chain " or swivel and powerful spring is attached; this being wound up by means of a *spanner*, a key is retained in that position by a spring-catch connected with the trigger. A piece of pyrites is firmly screwed into the *cock-head*, which on being pulled forward rests on the circumference of the wheel, which enters the bottom of the pan. On pulling the trigger the wheel is disengaged, and spinning round in contact with the pyrites, it produces a stream of sparks close to the touch-hole."*

FLINTLOCKS appear to have been introduced into our armies about the third or fourth year of William the Third (1692-3), since which time they remained in use, with very little alteration, up to the period of the discovery of the percussion principle by the Rev. Mr. Forsyth. It is quite unnecessary to describe a contrivance so well known as the common flintlock; just as unnecessary is it to describe the common percussion lock of the present day,† although it has undergone many changes of form since the discovery of Forsyth. Suffice it to say, that the advantages of the percussion over the flint principle are now universally established, and muskets of this construction are either already introduced, or about to be introduced, into every European army.

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* Wilkins.

† It may be as well to state that the powder originally used for charging percussion caps was a mixture of chlorate of potash and sulphur. This was, however, found to destroy or corrode the lock, and now the *anti-corrosive powder*, or mixture of fulminate of mercury, is universally employed.

We have hitherto designated small arms, in contradistinction to artillery, by the general term *musket;* this, however, was merely for the sake of convenience; various are the appellations that have been given to manual fire-arms, some of which we will proceed to describe. The first small fire-arms were called HAND-CANNONS, and were fired on a rest by the manual application of a match. When the weight of these instruments was reduced, and a lock appended, so that they might be fired without a rest, they were called CALIVERS.

It is supposed that the most ancient kind of fire-arms mounted upon a stock was the ARQUEBUSE,* and the invention of it is placed about the year 1500. These instruments succeeded the hand-cannons, or culverins, in field service, and restricted the use of the latter to sieges. Such hand-cannons were afterwards called *arquebusque à croc* (arquebus, with hook), in consequence of being provided with an appendage of that kind. In our statutes it was called "arquebuse," "haquebus," and "hagbut." The term *musket* was originally applied to a fire-arm larger and heavier than the caliver, and therefore supported when fired by a rest. The PETRINAL, or POITRINAL, was an arm shorter than the others mentioned, and of larger calibre; it was fired resting against the breast, and hence its name.

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* There appears to be no just ground for considering the harquebuss and caliver as different weapons. "It is supposed by many" (says Barwick, p. 8) "that the weapon called commonly a caliver, is another thing than a harquebuze, whereas in troath it is not but onely a harquebuze, sauing that it is of a greater circuite or bullet than the other is of, wherefore the Frenchman doeth call it a *peece de calibre*, which is as much as to say, a peece of bigger circuite."

PISTOLS are so called from Pistoia, in Etruria, where they were manufactured anterior to 1544, in the reign of Francis the First. The German horsemen called *reiters* were the first who extensively employed the pistol, having discarded, in favour of this weapon, the long-used lance, and incurred for that reason much censure, and even abuse, the innovation being considered to some degree dishonourable, and opposed to the established laws of chivalry.

Anciently, not only were fire-arms large and small used to project bullets, but wooden arrows, called *sprites*, and steel quarrels were also employed.* The recent MUSKET is so obviously the derivative from the ancient small fire-arms, that all description of its nature and construction will be unnecessary. The RIFLE-GUN, however, differs from all other fire-arms in a very important particular, which we must now describe. Owing to a variety of causes, bullets from common barrels fly very wide of their mark. In the first place, they are seldom correctly cast, or if so originally, they soon become imperfect from wear and pressure, hence the air re-acts on them very unequally and deflects them from their intended course. Again, not touching equally every side of the barrel, they are subject to another great cause of irregularity. The rifle-gun counteracts these injurious tendencies by imparting to the ball a spinning motion on the axis of its line of flight, and thus presents every part of the ball (except the two axes) in the same direction successively; thus any natural imperfection in the ball is compensated for, whilst, owing to its fitting the barrel closely, it touches every part alike. This peculiar spinning motion is imparted to the ball by very obvious means. The interior of a rifled barrel is cut in spiral grooves,—in point of fact it is a screw, into the furrows of which a leaden ball is either indented or cast originally to fit; thus it cannot be projected straight out, but emerges spirally, which motion is continued throughout its course. Hence a rifle-ball is projected with far greater accuracy than a ball from a common gun, but it is not necessarily, as some suppose, urged further;—indeed, in the case of old rifles using spherical bullets, not so far.

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* See Sir Richard Hawkins's account of his voyage to the South Sea, A.D. 1591, p. 164, sect. xvi., where he mentions shooting arrows from muskets with great success.

ON RIFLE-GUNS.

If a common musket-barrel be fixed in a vice, in such a manner as to prevent all motion, loaded and fired several times in succession at a target situated at one hundred yards distance, the bullets will err from the line of sight much more considerably than might *à priori* have been imagined. Instead of hitting the exact point aimed at, some will impinge above it, some below, some on each side. Nor will the errors be trifling under these circumstances, but may amount to two feet, or even more.

It is evident, then, from a consideration of this fact, that with an aim so radically defective, quickness of eye in the soldier is a quality of but limited application. If we remove the target successively to greater distances the errors of deflection increase to an amazing degree, so that at a distance of six hundred yards a musket-bullet frequently wanders from its aim to the extent of many hundred feet.* This is no new discovery—it was known to that accurate experimenter Robins, who mentioned it in his work on Gunnery, written in the year 1742; but the fact has never gone forth with the emphasis it merits, much less has it been taken cognizance of as an accepted axiom.

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* *Vide* page 102.

The reason of this inequality of flight is not difficult to explain,—being referrible to the ever-varying conditions under which a bullet flies through the atmosphere when shot from a common gun. In the first place, although intended to be spherical, no bullet is absolutely so; and in proportion as it deviates from perfect sphericity, so will the atmospheric reaction encountered during its flight cause it to deviate from its calculated path. Then, again, a further amount of deflection will be determined by the condition under which it leaves the gun. Should it, for instance, touch the right-hand side of the barrel last, it then will rotate on a vertical axis towards the right, and its line of deflection will also be to the right of the calculated path. Should it happen to touch the left side of the barrel, the reverse of these conditions will obtain; and so on for the varying conditions resulting from its final contact with the upper or lower side of the barrel.

Instead of expatiating tediously on the nature and cause of these deflections, let us cite some parallel cases, illustrative of the case in point. The first, then, that occurs to us,—and it has somewhat of a military aspect,—is this. Leaden shots are made by pouring melted lead, mixed with a certain amount of arsenic, through a kind of sieve. The result of this operation is intended to produce little *drops* of fused metal, which, falling into water, shall become round shots.

Now, by far the larger number of these melted drops do become round as desired, but a certain portion are not round, but pyriform—something in shape like a boy's peg-top; and the *round* shots are separated from the *peg-top* shots by the following very simple process. The whole mass of shot is made to roll down an inclined plane, when the round ones find their way in a straight line to the bottom, but the *tailed* ones diverge to one side. Now, a tailed or peg-top projectile would also shuffle a good deal on one side if fired from a gun, as the reader will not fail to understand; and in proportion as any bullet differs from perfect sphericity, so does it assume the aspect of a peg-top.

Assuming all deviation from perfect sphericity to have been obviated, of course this source of aberration could no longer exist; but there would still remain another, as we have seen.

Referring once more to our shot-sorting inclined plane, the reader will be at no loss to comprehend, that if the tailed or peg-top shots, could have had imparted to them the ordinary spinning motion of a peg-top,—then in that case there is no reason why they should not have rolled down in company with their spherical neighbours. The application of this fact we shall see by and by.

The rifle-gun is an ingenious contrivance for converting the undefined and irregular motion of fire-arm projectiles into one predetermined and regular; by imparting in point of fact a spinning top like motion to the bullet, and thus ensuring its continuance in a vertical trajectory curve. It is strange, however, that although the rifle principle is founded on the idea of a spinning top, yet, until very lately, the spinning motion was imparted to a round bullet merely, and not a projectile fashioned like a top.

The general aspect in which a rifle differs from a common gun is this. Whereas the latter has a smooth cylindrical bore, the former has a bore not smooth, but cut into little grooves or indentations. This is the sole peculiarity a first glance will disclose; but if the observer unscrews the breeching of a rifle-gun, and looks through the barrel, the grooves in question will not be found to proceed straight from nozzle to breech, but to assume the direction of a very wide spiral; the screw of the spiral making one turn in about forty diameters. Now, it is evident that a bullet, or plug of lead, closely wedged into a barrel of this kind, and made to pass along the bore, must, except an extraordinary degree of violence be applied, follow in its course the direction of the spiral, and if propelled through the barrel by the force of gunpowder, must fly through the air in a spinning or top-like manner. This is the effect of the rifle-gun: this is the mode of flight of a rifle-ball.

The great correctness of a rifle over a common gun is too well known for comment. We will therefore not expatiate on this subject, but proceed to examine more closely the philosophy of the instrument, the laws which regulate its action, and the causes which have tended to limit its application.

In the first place, it must be evident that the rifle must be considerably more difficult to load than a common gun; also, that the act of loading must occupy a longer time. The very principle on which the instrument depends demands that the bullet should fit tightly in, and this tightness, under all usual circumstances, is effected by employing a bullet slightly larger than the bore. This bullet being first driven in by a mallet, and finally rammed home by a powerful ramrod, the loading is complete. Unquestionably, then, the rifle in this form is a much more troublesome weapon to manage than a common musket; more tedious to charge and discharge; less adapted, therefore, for pouring in upon masses of troops volleys quick and unflagging. Hence, almost coeval with the first invention of the rifle was the attempt to charge by an orifice at the breech, and various contrivances for this purpose may be observed in rifles of early construction. Generally speaking, all these contrivances have not realised the hopes of their suggestors, chiefly because of the difficulty of making the necessary joints impervious to the gases resulting from inflamed gunpowder. Indeed, the same objection applied until lately to every variety of breech-loading gun, but it may be questioned at this time whether the objections have not been obviated.

It would be out of place here to describe the means by which the rifling of gun barrels is effected; but enough will have been said to convince the reader that the engraving of these long spirals is a matter of great delicacy, and that if these spirals be not absolutely parallel one with the other, the object for which they were made will have been lost, and the rifle, falsely now called, will have become something worse than a common gun. A rifle, in point of fact, is a somewhat delicate pneumatic instrument, unfit for clumsy hands, and only efficient when treated with care.

With respect to the number and depth of the rifle ridges—grooves, or lands, as they are called—this is a matter of taste to a great extent. Provided the theory of the rifle be kept well in mind, so that loading be accomplished in such a manner as shall ensure the bullet acquiring the spiral turn—provided that the rifle has, in the first place, been truly grooved (without which all care is thrown away)—almost any rifle may be made to shoot with sufficient correctness for military purposes; that is to say, may be made to hit a man, when fired from a vice or other fixed object, *infallibly*, at a distance of four hundred yards. For military purposes, however, rifles having small delicate grooves are objectionable, being subject to injury from the iron ramrod employed, and moreover being liable to the accident of allowing the ball to *strip*, as it is called technically—viz., to issue straight from the barrel without assuming the spiral turn.

Whatever the diameter of the bore, or calibre of the piece may be—whatever the length of the barrel—whatever the other peculiarities, the first thing to be borne in mind in the purchase of a rifle is, that the rifling itself be accurate. With a view of testing this, it is a custom in some parts of Germany to proceed as follows. Into a short cylinder of rifled barrel, corresponding to that of the gun itself, lead is cast, so that when withdrawn cold it forms a rifled cylinder of lead, which being oiled, thrust into the barrel, and forced through it, the relative degree of ease with which it passes enables the operator to judge of the ease with which the rifling has been made. If the leaden cylinder meets with no impediment in its way, but goes equably through the barrel from one end to the other, the gun may be accepted provisionally; if, on the contrary, any irregularity of motion or obstruction be encountered, it is rejected. This mode of testing a rifle barrel should only be regarded as provisional; the *experimentum crucis* is this. Supposing a single-barrel rifle to be in question—(and single-barrelled rifles are always, *ceteris paribus,* more correct than double-barrelled ones)—proceed as follows. Load it properly (full directions for loading will be given by and by), then, having fixed it securely between the chops of a vice, securing the barrel from damage by two sheets of lead, point it accurately to the bull's-eye of a target, at a short distance, say 80 yards, or whatever may be the distance of the first sight, then fire the charge. If the bullet go straight to its mark, and if, repeating the experiment again and again, the same result occurs, the barrel may be considered so far good. The operation should now be repeated at progressively increasing distances, say 100 yards, 150 yards, 200 and 300 yards. 100 yards may be considered as the average point-blank range for rifles, beyond which distance the bullet, although it never ought to depart from the vertical trajectory curve, will strike below the line of sight, extending from the level of the breech to the level of the muzzle. In other words, the barrel must be elevated in proportion to the distance of the shot. Now, this elevation is determined in rifles by sights of various lengths. We will suppose the experiment of firing from a fixed rest to be now repeated at 200 yards, or at any other distance corresponding with that engraved on the sight. If the bullets hit the bull's-eye at this distance the gun is of good quality; or if the bullets strike in the same vertical line, somewhat over or under the bull's-eye, there is no radical defect. If the bullet strike over the mark at this distance, but accurately at the distance of the short sight, whatever this may be, then the error may be presumed to depend on the sight in question being too high, and therefore giving too much elevation. The remedy for this is simple and obvious—the sight should be made shorter.

If the bullet shoot invariably right or universally left of the mark, then the error probably depends on the sight being not exactly situated in the medial line of the barrel; the remedy again in this case is obvious. If the bullet strikes below the bull's eye, but in a line vertically coincident with it, then the error may arise from one of two causes—either the sight is too short, or the charge of powder is too small.

In this way the rifle should be tried for every distance marked upon the sights, after which practice may be made at intermediate distances, so that the rifleman may at length acquire a thorough confidence in his weapon, based on a knowledge of its range and power.

The remarks hitherto made are general, not specific; they apply to all guns on the rifle principle. We will now offer some remarks on rifles individually.

THE MOUTH-LOADING RIFLES.

Notwithstanding all the contrivances which have been had recourse to for the purpose of loading rifles at the breech, the mouth-loading rifle is still most general; hence we have chosen this particular variety as the subject of our first remarks.

The hammer being yet on the nipple—the latter without a cap—charge the piece with the quantity of gunpowder previously ascertained to be the best; then, supposing a leaden bullet to be the projectile to be employed, proceed as follows: lay flat on the muzzle of the gun a piece of linen, silk, or glove leather, greased on the side touching the muzzle, and in size just equal to the exterior diameter of the barrel. On this piece of linen, silk, or leather, lay the bullet, and force the whole down upon the powder. This is effected usually by the aid of a little mallet, to force the bullet into the barrel, and a ramrod to drive it home. The mallet, however, may be dispensed with. The gun is now capped as usual.

Great care should be taken with all rifles not to injure the grooves or lands during the operation of ramming down the ball. Sportsmen have long abolished the use of iron ramrods, on account of the damage they thus produced; but military rifles, ever in the rear of improvement, still have this instrument, so destructive to the accuracy of their pieces. If it be necessary to retain the ramrod of iron in the military service on account of the strength of this material, the end should at least be tipped with brass.

Some people are in the habit of loading rifles without the *patch* above described; but, except in some rare cases, hereafter to be spoken of, the plan is reprehensible.

This would seem to be the best place for adverting to the most vicious system of rifle-loading pursued in some of our London galleries, where, for the sake of economizing time, the bullet without any patch is violently forced down upon the powder by an iron ramrod, provided with a heavy iron knob at one end. Rifles thus treated are totally ruined in a short time, their grooves becoming torn, ragged, and faulty.

THE BREECH-LOADING RIFLE.

Doubtless, if all mechanical difficulties could be sufficiently overcome, the breech-loading principle for small fire-arms would deserve preference over the common method. Not only would time be greatly economized by loading at the breech, but the noise and mechanical exertion incident to the driving home by a ramrod a bullet on its charge, are both by the breech-loading principle entirely obviated; and, more important still, in a military point of view, the act of charging fire-arms of this description can be performed by a soldier lying flat on the ground; whereas the common or mouth-loading rifle involves the necessity of his rising up, and exposing his whole body under the most favourable circumstances to the enemy's sharp-shooters. This latter is the most serious disadvantage of all, and its value should be maturely estimated, and deliberately weighed against certain objections presently to be noticed. These remarks apply equally to every variety of breech-loading contrivance. Let us now proceed to investigate these contrivances in detail.

VARIETIES OF BREECH-LOADING CONTRIVANCES.

These are exceedingly numerous, and many of them very old, more especially in respect of rifles, the mechanical difficulty of ramming down a ball into which was stimulative of a means to render this difficulty unnecessary. One powerful objection to all fire-arms of this description, is the difficulty of making the joints, rendered necessary by the apparatus, sufficiently light to restrain the escape of a portion of the ignited gunpowder. Another objection consists in the facility with which all moving gear, however well constructed, gets out of order by rust and foulness when exposed to a prolonged contact with the flame of gunpowder.

Without impugning the superiority of the breech-loading principle, we can easily understand why it did not come into favour in the earlier days of fire-arms. This principle includes a great deal of perfection in mechanical workmanship—a perfection altogether foreign to the ordinary necessities of the ancient gunmaker; and modern artizans may not have had their attention directed to the elaboration of this principle, owing to a combination of many circumstances. In the first place, it is conceded that the mouth-loading principle would be superior to any other, were it not for the manual labour, the time, and the exposure to adverse attack, during loading. Now, in rifle sporting practice, these objections vanish; and as regards military rifles, the system of government contract for low-priced arms is unfavourable to the development of any refined improvement. By no means, then, are we warranted in impugning the principle of breech-loading arms, by reference to past experience alone. And the argument frequently brought against this variety of fire-arms, to the effect that although they might answer in the hands of an educated sportsman, they would not under the management of an uneducated soldier, is based on the postulate that soldiers must of necessity remain uneducated,—and is totally invalid when brought to bear on the case of a volunteer. Indeed, when taking a cursory glance at the great improvements which have recently been made in small arms of fire, we are constrained to recognise that every step in this direction confers additional power on the educated and intelligent man over the mere drilled automaton of an ignorant soldier. If fire-arms be recognised as the best means of projectile offence and defence, it will scarcely be doubted, we presume, that in an attempt so sacred as the defence of our homes (the only justifiable form of war), the fire-arms employed should be of the very best quality, and each rifle specially adapted to the eye, the arm, the physical strength of its possessor. Now, the mere expense incidental to the arming of standing troops in this way, would be far beyond the power and will of any Government to incur; therefore, if the latest improvements in fire-arms are to be made available, this must be accomplished by volunteers.

It would afford curious materials for contemplation, were we to speculate on the connection between standing armies and ill-constructed arms. Referring to the period when the long bow was the cherished weapon of England, we find there were no standing armies then; and a slight consideration will demonstrate to us that a standing army of archers would have been impossible. We have already seen by what stringent enactions every Englishman was formerly obliged to practise himself in the exercise of archery, with a bow of suitable size and strength. Had bows in those days been delivered from the armoury of equal length and equal power, without reference to the tallness or shortness, strength or weakness of the archer, we may accept as granted the assumption, that our fame in archery would never have acquired a world-wide repute. Moreover, the very act of using a long bow, could not be acquired by an adult altogether unused to the arm.

In point of fact, the whole system of archery was antagonistic to the very principle of standing armies, and could only have arrived at perfection under the emulative and fostering care of volunteers. Now, we cannot see why, at the present time, England should not have her expert riflemen, as she once had her volunteer archers; we cannot see why the practice of arms should not form part of every educational course in schools; we cannot see why every adult should not have, and be familiar with the use of, fire-arms suitable to his age and strength. Thus provided, we might laugh to scorn the threat of invasion, an enormous expense to the country would be saved, and there would be little fear of our ever assuming the character of an aggressive force, for the disturbance of continental rest.

Whatever difference of opinion may be entertained as regards our general argument, there can be none, we apprehend, if our remarks be limited to the circumstances of the present crisis. It will scarcely be urged that varieties of fire-arms confessedly good in the hands of sportsmen, are not also equally good for volunteers. Let us therefore return from our digression, to enter in detail upon the leading varieties of breech-loading contrivances. These are very numerous, but three only merit any particular attention; and these we shall treat of rather *generically* than *specifically*,—rather as a matter of principle than of detail.

The first principle consists in the employment of a slide or screw motion in the side of the breeching, allowing a sufficient opening to be found for the insertion of a cartridge, after which the slide or screw is fastened again.

The second principle consists in the adoption of a hinge by which the barrel is secured to the stock inferiorly, in such a manner that it may be made at pleasure to bend down at an angle, when the charge can be thrust into the barrel, and the latter brought once more to the shooting position, secured by proper fastenings to the stock.

The third principle is combined with a repetition action, and consists in bringing successively, by adequate mechanism, a series of short cylinders containing the charge, in a direct line with a fixed barrel.

Now, of these separate types of breech-loading contrivances, we shall only remark, in this place, that the first is embodied in the celebrated Prussian *Zündnadelgewehr*, or needle gun; the second has been pretty extensively applied to fowling-pieces both in France and Belgium; and the third has now acquired a world-wide fame in connection with the celebrated repeating fire-arms of Colonel Colt, concerning which we shall hereafter have to offer some remarks.

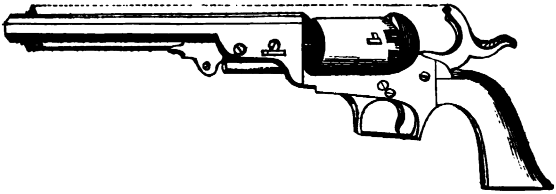
THE PRUSSIAN ZÜNDNADELGEWEHR, OR NEEDLE GUN.

This variety of fire-arm, concerning which so much has been said, is a most curious and, in careful hands, effective instrument. That it loads at the breech the reader has already been informed, but this is the least of its peculiarities. By a very ingenious mechanical adaptation, a long needle is darted quite through the gunpowder of the cartridge, against a portion of detonating material situated between the powder and the ball. As a consequence of this, the gunpowder burns from the front backwards, and consequently every grain is ignited, instead of a portion being projected, as occurs frequently in the case of ordinary guns.

After what we have already stated, the *theoretical* advantages of the needle gun require no comment, and the only point to be determined in practice is, whether they fulfil their theoretical indications. Now, the testimony on this subject may be shortly stated as this. In England, authorities say that if made they would not answer; in Prussia, however,—being made and largely employed, they are *found* to answer. That they would be adapted to the condition of an uneducated British soldier of the line, we could not undertake to say; but, granting that they would not, it by no means follows that they would be unadapted to the circumstances of the volunteer.

The second type of breech-loading gun may be summarily discussed from our consideration in favour of the third, or repeating breeching, the idea of which was entertained in England at least as early as the reign of Henry VIII.; but the successful application of which was, in a manner, impossible, until the disuse of flint and steel in favour of detonating powder as a source of ignition. Since then, numerous attempts have, at various times, been made, for the purpose of giving effect to the contrivance; but never, we believe, with perfect success, until Colonel Colt perfected his repeating pistols and carbines. As regards these arms, the principle may be considered as having been applied with complete success; but considerable doubt still exists as to its applicability to large rifles, intended to project a ball to long distances, and hence requiring a heavy charge of gunpowder.

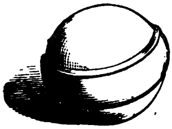
Inasmuch as a five minutes' inspection of one of Colt's pistols, or carbines, would render the theory of its construction a matter of complete ease, whereas a tedious amount of circumlocution would still leave the mechanism of the instrument obscure, we do not consider it desirable to enlarge on this topic. It is proper however, to remark, that within the last few weeks an English repeating pistol has been brought out (we



know not by whom), termed an improvement on the American model. This claim we consider to be founded in error; in our opinion the American pistol is greatly superior to its English rival. We present engravings of both—the first, of the American; the second, of the English pistol.

ON BELTED BALLS.

The great difficulties attendant on loading a rifle by the mouth with a common ball suggested the contrivance of casting the ball with furrows already made, fitting exactly to the lands or grooves of the gun. This contrivance has long been applied in Germany, but was first introduced in England by Mr. Lovell, and for several years the plan was adopted in the arms of the British rifle infantry, the fire-arms of which were two-grooved rifles, and the ball consequently having but one circular ridge was called the *belted ball.*

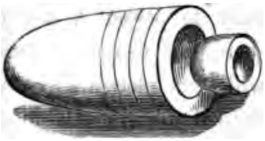


By using this belted ball there was no longer any fear of stripping, and an iron ramrod inflicts its minimum of damage on a two-grooved barrel. The British regulation rifle is still the same, but the belted ball has given place to a far better missile, namely,—

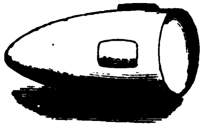
ELONGATED RIFLE PROJECTILES.

All our remarks hitherto have had reference to bullets or spheres of lead, a form of projectile which is the best unquestionably for common guns; but, supposing the rifle principle to be adopted, there is every *à priori* reason to assume that an elongated conical, or pointed missile would be far better than a bullet. Not only better on account of the ability to project a heavy weight of metal from a small bore, but also on account of the diminished resistance which an elongated body offers to the atmosphere, provided always the long axis of the projectiles be coincident with the line of flight, a condition which rifled motion invariably secures. At present our rifle brigade is armed with these conical projectiles, and also the riflemen of France, Prussia, and Austria; sportsmen, too, admit their great superiority, and indeed their use may be pronounced universal.

Very soon after the application of these conical projectiles, followed two important additions to them, both of which would have been totally inapplicable to the spherical ball. M. Delvigne, we believe, first made the conical tip of a piece of hardened steel, thus imparting to the lead an amazing increase of penetrating force, enabling it to crash through the skull of an elephant with ease, or perforate a rhinoceros. The effect of some of these projectiles against thick plates of iron might have been seen in the late Exposition, leaving us to speculate on the amount of protection that may in future be expected from helmets and cuirasses. Captain Minié still further improved the conical projectile, by an ingenious contrivance, enabling it to be thrust into the gun with ease, yet securing its perfect fitting against the barrel before its exit.

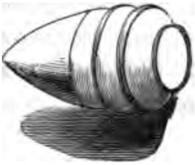


The conditions of the foregoing problem are so difficult at a first glance, that their solution might have been deemed hopeless; yet have they been solved by a very simple application of mechanical principles. The conical projectile is supplied with a conical hole, into the base of which loosely fits an iron thimble, or peg, against which the powder exploding drives it far up the orifice, expands the sides of the projectile close against the barrel, and tightly into the groves of the latter. Thus is the mechanical labour of charging an ordinary mouth-loading rifle rendered as easy at least as that of loading a common musket. Pellets, or conical projectiles of this kind, are now used by the *Chasseurs de Vincennes*, and bullets for rifled arms have now almost universally given place to conical projectiles, either hollow or solid. We append a conical solid projectile adapted to a four-grooved rifle.



OTHER VARIETIES OF RIFLE-BARRELS.

Instead of employing the expansion principle of Captain Minié, it has been proposed by certain gunmakers to accomplish the easy loading of military rifles by adopting a contrivance of the following kind: From the breech of the gun, and projecting up into the barrel, a cylinder has been inserted, thus reversing the ordinary conditions of the chambered or patent breech, and allowing the charge of powder to be peripheral instead of central. On this table or cylinder the bullet was made to rest, and it is evident that a bullet so situated, if violently beaten by an iron ramrod, would flatten out and fill the grooves. This plan was first suggested by Captain Thouvenot: it has never been largely adopted, and cannot be recommended. Various modifications of this plan have been adopted. For instance, the Minié bullet was at first intended to be used in connection with the *tige*-table, or anvil; but eventually it was found that the mere explosive force of the gunpowder served to drive up the thimble into the cone. Mr. Wilkinson, of Pall Mall, adopts the principle of furrowing the leaden cone with deep circular notches, leaving intermediate sheets of lead, which are assumed to be compressed by the discharge, and thus to fill up the rifle-grooves. We append a figure of the leaden projectile employed both in the *carabine a-tige*, and also in Wilkinson's stadia rifle.



ON SMOOTH OR ELLIPTICAL RIFLES.

The various inconveniences attendant on the wearing out of ordinary rifle ridges—the difficulty of melting the lead to fill them, and some other objections, have been admirably overcome by Mr. Lancaster. This gentleman has devised a rifle having a perfectly smooth but slightly elliptical bore; the result of which, both as regards accuracy, lightness, and extensive range, exceeds all that has hitherto been achieved in rifle practice. The ball, although fitting in perfectly air-tight, is urged home to its charge of powder with moderate and equable facility; and the total absence of grooves or lands renders the barrel very secure against the damage of casual bruises or scratches. This rifle is altogether of modern invention, and is not yet generally known; but all who have adequately tried its powers, yield it the preference over every other.

By adopting the use of conical or elongated projectiles, Mr. Lancaster has been enabled to reduce the bore, and consequently the weight of the gun itself. The double rifle made by this gentleman, projecting a leaden pellet of 346 grains to the pound, only weighs 8 lbs.

ON THE KIND OF GUNPOWDER TO BE USED IN RIFLE PRACTICE.

It is a very common, but most erroneous opinion, that very fine ground gunpowder is necessarily the strongest. Nothing can be farther from the truth, as regards rifle practice. In order to decide this question, let us examine the extreme case of the employment of mealed powder, *i.e.*, gunpowder reduced to an impalpable state. In this condition, if removed tightly into a barrel and ignited, it does not explode suddenly, but by degrees, after the manner of a squib. In point of fact, the main condition of effecting rapid explosion is the presence of a certain amount of atmospheric air throughout the charge of gunpowder, and between its grains. Of course a medium must be followed in this. The grains may be so large that they shall in parts be projected without ignition; and the other kind may be so small, so close together, that their ignition shall be too lingering for the generation of a projectile force. As regards fowling-pieces, probably small ground powder is the best, inasmuch as the shot meeting with no obstruction on account of friction against the barrel, are expelled immediately; but in rifles, where the bullets or other projectiles are tightly impacted, it is desirable that the fire-blast shall have pervaded the whole mass of powder, before the ball begins to move. This is best secured by the use of a moderately coarse powder; not powder of impure components, as is the case with much gunpowder of similar physical aspect, but a material prepared specifically for rifle-practice, and known in the shops as rifle-powder.

ON SUBSTITUTES FOR GUNPOWDER AS A CHARGE FOR ARMS OF FIRE.

ALTHOUGH no compound has yet been discovered at all, competent to supersede gunpowder, various materials have been employed as matters of curiosity. Accordingly, in the gunmakers' shops of France and Belgium, and occasionally in England, we see pistols and small carbines designed to propel their bullet by the mere explosive power of a very large cap, attached already to the bullet or cone; and the latter being inserted at the breech, the act of charging is conducted with great rapidity.

When the calibre of the fire-arm is very small, such, for example, as of a pea-rifle or a pocket-pistol, the contrivance in question answers very well; and as the result of explosion is totally devoid of smoke, and moreover leaves no residue, fire-arms on this construction are well adapted for practice in close apartments. Viewed, however, as a means of propulsion for rifles and pistols of larger bore, the plan just described is totally useless; and, if not useless, would become highly dangerous in practice.

The substance gun-cotton, immediately after its discovery, was thought capable of superseding gunpowder as a propellent, but repeated experiments have demonstrated, what any one conversant with the law of fire projectiles could have predicted—the total inadequacy no less than danger of gun-cotton.

Moreover, if this substance could be used with safety, and if its power were adequate, the great argument for its employment, viz., its non-destructiveness to the barrel, still remains invalid. Gun-cotton, it is true, yields no smoke, and therefore to a non-chemical eye it would create the idea of not damaging the barrel; but it yields fumes of nitrous and nitric acid, both eminently destructive to iron.

We do not know whether any one has been rash enough to try gun-cotton as a charge for artillery, but its powers have been adequately tested in small fire-arms of various calibres, and the experiments have resulted in its complete abandonment. Its employment, also, when largely diluted with ordinary cotton, has been attempted in the manufacture of war rockets, but a frightful accident, which occurred during the operation of charging one of these missiles, led to an abandonment of the material. It has been also tried in the operation of rock-blasting, for which it presented the great advantage of not clouding the narrow shafts and outlets of the mine with smoke. Even in this limited sphere of application, however, we believe gun-cotton has been found too dangerous for employment, and, so far as we know, its complete abandonment has been the result.

ON THE FORMATION OF RIFLE CANNONS.

Having already described the principle on which the rifling of small arms depends, and the mechanical difficulties connected with the act of charging them, it will be easily understood that still greater difficulties will be encountered in applying the principle of rifling to cannons.

In the first place, we have seen that a rifle projectile must, almost of necessity, anterior to the discovery of the smooth oval-bore rifle, have been made of lead, or some other yielding metal; and it will at once be recognised that leaden canister projectiles (balls or bolts) would be unfitted for all purposes of battering down walls. As a counterbalance, however, to this objection, leaden projectiles, being heavier than iron, would afford a longer range for an equal calibre of gun; hence they would be superior in effect against ships and against troops. We may, therefore, safely assert, that the mere necessity of making cannon-balls of lead would not have prevented the use of rifled cannon, under some exceptional circumstances, had no other difficulties interposed.

The greatest of all difficulties consisted, doubtless, in the loading of such cannon. To force down the bullet of a small rifled fire-arm requires a considerable expenditure of mechanical exertion; how much more difficult must it necessarily be to perform a similar operation in loading a rifled cannon? Indeed, supposing the employment of rifled cannon to be determined on, there would appear to be no resource open to the inventor but that of breech loading; and that is an operation so difficult to be achieved, that when a Swedish breech-loading cannon was shown in the Great Exhibition, artillerists hurried to examine it with wonder and admiration. But the theorist may here interpose, by a remark that the problem having been solved, it can be now practically turned to account,—that what has been done once may be commonly done. We doubt it: the Swedish gun was made of wrought iron, and may be regarded as a triumph of successful welding;—a cast-iron breech-loading gun of equal size would, we imagine, be eminently unsafe, and brass or gun metal would be far too soft to admit of the necessary joints being retained air tight. We are sceptical, therefore, as to the possibility of using in active service breech-loading cannons.

Hence we are driven to adopt the mouth-loading principle, which, until the discovery by Minié of his expansive bullet, and until Mr. Lancaster's most ingenious device of employing an elliptical bore, might be pronounced hopeless. Now, it will be seen that the adoption of the expansive bullet is limited to the employment of lead as a projectile; whereas, there seems no difficulty in recognising the possibility of employing projectiles of cast and wrought iron, supposing cannons to have been rifled on Lancaster's oval-bore principle. We learn, indeed, from Mr. Lancaster, that he has already obtained important results by the application of his oval-bore system to great guns.

Supposing the rifle principle to be successfully applied to cannons, still it is probable that the uses of this variety of artillery would be more limited than popular ideas might indicate. Longer range and greater precision would undoubtedly be secured, but the principle would be limited to simple non-scattering projectiles, or, if applied to the projection of canister, a spherical case shot would be so applied at a disadvantage as compared with ordinary artillery.

The reason of this will be obvious when we consider that the various components of canister and spherical case shot would be scattered by means of the rifled spinning motion so far laterally by the effects of centrifugal force, that the concentration of their discharge would be sacrificed.

Nevertheless, rifled cannon may, we doubt not, be turned to account under certain special conditions. Our coast defences, for example, may be supplied with cannons of this description, the projectiles of which might be made effective against adverse fleets, at distances and with a degree of accuracy far beyond anything we at present know of. By this means, ships may possibly be sunk long before they could fire an effective shot in return.

THE BAYONET.

THIS weapon seems so plainly indicated as an addition to the musket, and is so simple, that our wonder is at first excited at its application having been delayed until a comparatively late period. Not much reflection, however, is required to show that until the weight of the first small fire-arms had been considerably diminished, the bayonet, even in its present improved form, would have been a useless appendix. The idea of the bayonet originated in the practice which once prevailed of thrusting the handle of a short dagger in the muzzle of a gun after its discharge; thus it might be made to act as a pike. Such bayonets,* or daggers, as these were, according to Père Daniel, introduced into France about 1671.

The present mode of fixing the bayonet was a late discovery, having first been applied by Marshal Catinat in 1693, at the battle of Marsaglia, on which occasion the slaughter was immense. Notwithstanding this success, it was not until two other great victories had been achieved by them—namely, the battle of

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* So called from having been originally manufactured at Bayonne.

Spires in 1703, and that of Calcinata in 1705—that they were adopted by other nations. The introduction of this weapon led to the disuse of the pike, which was abolished by royal ordinance in France, in 1703, with the advice of Marshal de Vauban. We do not know the exact period when pikes were laid aside in England, but we believe about the same time.

When small fire-arms were first introduced, those who bore them seem to have carried their ammunition and charged their pieces just as pleased themselves. Some used cartridges, some flasks, and all were under the necessity of employing for priming mealed powder, then called touch, tutch, or serpentine powder. As for the ancient method of charging small fire-arms, an old writer intimates that all *good* musketeers, caliverers, &c., thrust in paper, or something equivalent, between powder and ball, but more particularly on the ball. He attributes a frequent failure of shots to the circumstance that, for want of paper thus thrust down upon the ball, the latter frequently rolled out.* We learn, then, from this, that the practice was anything but universal, and we may judge how ineffective must have been the shooting. In the reigns of James and Charles the First, was introduced an appendage for facilitating the charging of muskets, called the bandalier.* It was a broad belt thrown over the left shoulder, and hanging down on the right side. This not only served as a support to the fire-arms, but had suspended from it a dozen boxes, each of which contained one charge of powder, and also a bag for balls. The bandalier, however, was both cumbrous and dangerous; often would its boxes get entangled; not unfrequently they would ignite and explode; while their rattling against each other often betrayed the soldier to the enemy.

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* It may not be uninteresting to present the reader with a quotation from William's Discourses of Warre, descriptive of the management of ancient small fire-arms. "But here it may be demanded what I doo call the well charging of pieces of weapons of fire? Whereunto I answer that I doo allow neither harquebuze nor mosquet for well charged in services of the fielde, unless they bee charged with conuenient charges of powder, and with soft browne paper, or the refuge endes of matches, or something else to restraine the same, and likewise vppon the bullet the like or more quantitie to keep close, and restraine the bullet: or when, at the least, I would that some such thing should be thrust upon the bullet with the skowering

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stick, to keep the same close to the powder." Then he proceeds to advise that the bullets should not be too small, but should fit the barrel exactly.—P. 136-7.

* See Frontispiece.

ON NOVEL APPLIANCES OF WAR,

PROPOSED OR EXECUTED,

SO FAR AS RELATES TO PROJECTILES.

Having attended to most of the circumstances which limit the range of projectiles, we propose now to state, as shortly as is consistent with truth and justice to the subject, the means which have been proposed to increase this range; we will also mention the results of these suggestions, so far as they have been carried into practice, and will discuss the probability of the existence of methods said to be kept secret, and the chance of the discovery of others.

We have already alluded to the common supposition that chemical science may present the artilleryman with some substance that is, in common parlance, "stronger" than gunpowder, and that by this means a vast increase of range may be effected. We have shown the futility of this opinion; we have proved that chemists disclaim any such knowledge; we have demonstrated that if they should claim to be the depositaries of such a secret, the mathematician and practical artilleryman would treat the statement with unbelief, and justly, too, because it is in opposition to incontrovertible laws. As well might a chemist say that he could annihilate the attraction of gravitation, as that he could elaborate such a peculiar composition as gunpowder.

It may be said that chemistry is a field whose treasures are but little known; that although such explosive compounds as chemists generally are aware of may be inferior in propulsive force to gunpowder, this mere fact is not sufficient in itself to warrant a supposition that some peculiar composition of exceeding potency may not be discovered and held in secresy by one favoured individual; still *our* objection applies not the less. There is a point beyond which no increase of primary force can increase the range of a projectile, *and this point is far within the limits which circumscribe the force of gunpowder.*

We are justified in asserting, then, that far advanced as are all sciences connected with military engineering, in the present day, very little increase of the range of common ordnance (we mean cannons and engines of that class) will be effected; and that this little will be accomplished, not through any new composition of gunpowder, but as a consequence of improvement in the mechanical construction of missiles, and their projecting ordnance.

The longest range and greatest velocity ever accomplished by any ordnance, ancient or modern, up to the period of 1840, and we believe to the present time, is 5,720 yards, or just three miles and a quarter.

The whole time of flight was only thirty seconds and a quarter, which is estimated at 2,100 feet, in the first second of time. The piece of ordnance used on this occasion was a fifty-six-pounder cannon, cast on the principles of Mr. Monk, who suggested the propriety of removing a considerable proportion of useless metal from the gun before the trunnions, and adding it to the breech, where alone increased strength is desirable. This arrangement permits the use of a larger projecting charge of gunpowder, without risking the calamity of bursting. The quantity of powder employed in the experiment alluded to was ten pounds, and *the ball weighed sixty-two pounds and a half*, a circumstance which requires some explanation, seeing that we have stated the gun to be a fifty-six-pounder. The explanation is this: the momentum of a projectile is the product of its mass and its velocity; by increasing that mass, therefore, or, in other words, by adding to its weight without adding to its size, we acquire a proportionate increase of momentum, and a consequent increase of range. The shot on the present occasion was an iron shell filled with lead; hence its weight of sixty-two pounds and a half.

Nearly the same range was accomplished by the French during the Peninsular war, who threw shells into Cadiz, rather more than a distance of three miles; they, however, used enormous mortars, one of which is at present in St. James's Park, and employed the largest charges of gunpowder ever known in modern times; the missiles projected, moreover, were shells *nearly* filled with lead, the remaining space containing gunpowder ignitible by a fuse as in the common shell.

The fact that leaden balls accomplish a longer range than iron ones, seems to have been discovered at least *once* by chance, the discoverers being totally ignorant of the principles on which the circumstance was founded. It is related that during the war an American ship having expended all her cannon-balls, and being unable to procure others of a similar kind, had some prepared of lead; when on employing them in a subsequent action, her captain and crew were surprised at their long range and efficacy. Sir Howard Douglas is so satisfied of their advantages on peculiar occasions, that he recommends their introduction in the navy.*

Amongst the suggestions which naturally present themselves for increasing the range of a shot, a very obvious one seems to be the diminution of its windage, or the space which exists between it and the inside of the gun. Thus is reduced to a minimum the loss experienced by the escape of the gunpowder around the sides of the ball. That short kind of ordnance, the carronade, is made to embrace this amongst other principles, and the result of practice fully warrants, in this case, the justice of the theory. To long guns, however, the rule does not apply,—a fact which may seem strange at first, but which can be easily explained. With very great velocities and long guns there is a large column of air to be displaced before the ball leaves the gun, and which is condensed with great rapidity by the force of the ball, to which it offers immense resistance if it fit the gun closely. If, however, the size of the ball be reduced, the air has more space to rush round it, and the ball more easily escapes.

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* Naval Gunnery, p. 60.

Believing as we do that no considerable increase of range, from guns of the sizes at present in use, will ever be acquired, the question still remains unanswered whether such increased range may not be achieved by other means. For the sake of precision, we will assume this increased range to be six miles, and will ask whether such can be accomplished by any method, or combination of methods? We do not regard it as totally impossible; we see no primary law of nature against it, although we recognise difficulties so grave, and so numerous, as to check even the wild excursions of our fancy; and we are not theoretical enough to forget that even the mere possibility of this range granted, its military application is quite another thing; —involving considerations of facility, expense, and amount of scientific acquirement; besides a thousand and one others, all separate from the original question. As to the *possibility* of such a range, stripped of all accessory and contingent difficulties, our opinion is in the affirmative, although we are aware that the investigation of others, more practically conversant with these matters than ourselves, does not lead them to a similar conclusion. If a cannon-ball, when its flight was nearly expended, could meet with some aërial gun to urge it forward again,—if, in other words, its flight could be made to depend on two or more consecutive impulses, instead of one primary shock, its range would be evidently increased. Now, in reality, these desiderata are to a great extent accomplished by the rocket, which carries its own propelling agent with it. The question, whether a cannon-ball, of the largest present size, can be shot six miles, involves a primary law of nature,—a law which must be suspended before the question can be answered in the affirmative, and which consequently is an impossibility. The question, whether a rocket can accomplish this distance, involves no such suspension of a natural law, and no such impossibility. The rocket presents us with certain theoretical conditions necessary for the end in view; it remains to ascertain whether they can be sufficiently elaborated.

But in thus ideally suggesting a probable range of six miles, we need not assume the necessity of any increase of range either of gun or rocket. We will suppose a missile to be formed of a combination of one ball and two or more rockets; this missile first to be projected from a gun, during which a fuse is to be ignited, and to burn during its trajectory course, in such a manner as to ignite the first rocket. This rocket is now to free itself from the ball, which falls; the rocket proceeding in its course, and eventually igniting the other rocket; this last accomplishes the termination of the distance.

All this may be assumed as possible, although involving thousands of difficulties to which we do not require to have our attention drawn. In short, we are not visionary nor sanguine on the subject, and could fill half a dozen pages with difficulties and objections to the scheme,—yet we see no reason why it *must* be regarded as impossible.

The attention of the public was some years since on the *qui vive* about long ranges; being directed to this subject in consequence of the circumstances disclosed by Mr. Warner, who probably had in view the very plan of accomplishing a six-mile range that we have already mentioned, inasmuch as he asserted that a two pounder gun made on a peculiar construction would be sufficient to accomplish it. Now, we well know, that, *cæteris paribus*, the longest range will be accomplished by the largest gun, and that a two-pounder cannon is smaller than any in our service; without intending any disrespect to any one, then, we may safely assert that to project a ball six miles from a two-pounder by the mere primary force of gunpowder is a physical impossibility; and that if such range be accomplished, and a two-pounder cannon be instrumental in accomplishing it, this can only be effected by some such plan as we have described. We have another reason for presuming Mr. Warner to have intended this to be the plan,—he disclaims most pointedly ever having asserted that he could project by means of a two-pounder *a cannon-ball* six miles; but he avoids stating that the two-pounder is not to be instrumental in projecting a missile of name unknown to that distance, and he requires a two-pounder peculiarly constructed.*

We here leave this part of the subject, and proceed to the consideration of some other improvements which have either been introduced or are proposed to be introduced to the warlike art. The mere projection of missiles by the force of gunpowder was a great discovery; the application of the same substance to the bursting of shells was an ingenious and useful extension of it, adding to the mere projectile force of the ball the devastation and the consequent terror of fire, together with the primary explosive power and disintegrating influence of gunpowder. When first shells were thrown from mortars, pyrotechnical science was not sufficiently advanced to render the period of their bursting at all certain; neither were the principles or practice of their firing well known. They were ill-constructed, ill-managed; and moreover a prejudice existed that the fuse must be lighted before the charge was fired, which added considerably to the danger as well as the trouble of mortar practice. These defects are now, to a great extent, overcome; shells are cast of equal weight, and their fuses correspond so well amongst themselves as regards time of burning, that the distance of projection being known, the time of bursting can be calculated with wonderful accuracy. When, however, it is considered that a small fraction of a second is on some occasions a matter of considerable importance, and that such an amount of accuracy is hardly possible to be expected from the use of the fuse, it will be evident that any simple and at the same time safe and effective plan of procuring the explosion altogether independently of the fuse, would be a desideratum. The various substances known to chemists as capable of exploding by percussion, favours the idea of a substitute. Could not a shell be filled with gunpowder, as is usually done, and furnished in some manner with an appendage—such as the copper percussion cap, for instance—which might explode when the shell struck the object, and thus ignite the contained charge? Instead of a shell furnished with a percussive appendage, could not the percussive material form part of the shell? These are amongst the most obvious questions which present themselves, and at a first blush they seem easily answerable in the affirmative; but a little consideration will develop many difficulties. There is no difficulty experienced in making a shell explode on percussion, but it is exceedingly difficult to make it explode when wanted. The primary impulse of the charge of the gun is in itself a strong percussive agent, and hence percussive shells as frequently explode immediately on leaving the gun as on striking their object. This is a very great disadvantage, although certainly not insuperable; a far greater one is the difficulty and danger of keeping such shells and conveying them from place to place, not under peculiar scientific charge, but subject to all the shakings, blows, and other contingencies of military and naval transport.

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* Mr. Warner's long range has, since this paragraph was written, turned out to be accomplished by a balloon bearing shells in its car!

This remark certainly does not apply to those shells which are furnished with a percussive appendage, but they are open to other grave objections. In a shell of this kind some provision must be made to insure the striking of that part of the shell which is furnished with the percussive appendage,—a matter in itself of no small difficulty as regards cannon, and which has yet only been accomplished by departing from the spherical and assuming the pyriform shape in the construction of the shell, under which circumstances the large end will point forward, and consequently strike the object first. Now, the united testimony of practical men is against the employment of non-spherical missiles, so far as relates to every variety of gun, and at long ranges, as being so exceedingly irregular in their flight that their use becomes most uncertain, and defies all calculation. At short distances, however, and especially for sea service, bar shots are, under particular circumstances, recommended. A small gun may thus be made to project great weight of metal, and thus to acquire a great increase of destructive power.

The remark only applies to cannon, and plain small arms: so far as relates to rifles, the difficulty has been entirely overcome,—or more correctly speaking never existed. An elongated or cylindrical body, properly fitted to the rifle and shot from it, maintains during flight that end forward which first emerged from the barrel, the reason of which is attributable to the rotatory motion it acquires. If, then, a hollow cylinder of lead, fitted to a rifle-barrel, be filled with gunpowder and furnished with a copper percussion cap, or some equivalent contrivance, it will act very efficiently as a percussion shell. Captain Norton has availed himself of the principle, and, in allusion to the contrivance, Mr. Wilkinson of Pall Mall, in his work on engines of war, p. 115, states,—"I never found one (*i. e.* of these shells) fail to strike on the foremost end, and explode at all distances from 50 to 300 yards. In one experiment I fired at two thicknesses of inch and a half elm lined with sheet iron, and containing between them a stratum of four inches of water; the shell passed through the whole at sixty yards' distance, and exploded a box of gunpowder on the other side." It will be seen, then, that so far as relates to rifled small arms, there is no difficulty,—but rifled cannon do not exist, although Mr. Lancaster and others are now endeavouring to construct and render them available.

Mr. Pasley, many years since, proposed a very safe and ingenious plan for making a percussion shell, the explosion of which was dependent on the fact, that air suddenly compressed liberates heat sufficient to inflame gunpowder. His shells were pyriform, for reasons already mentioned, and a cylindrical cavity terminating at the large extremity of the shell, was partly filled with gunpowder, and closed with a tightly fitting iron bar, which projected considerably beyond the surface of the shell, but which a sudden blow could force down after the manner of a piston, and thus ignite the powder. These shells were tried at Woolwich, and condemned chiefly on account of their departure from the spherical form; although it would not be difficult to point out other disadvantages. For instance, the quantity of gunpowder such a shell could hold would be very insignificant, and the bar would be very liable to get fixed from rust, &c.

We have hitherto supposed that the shell is to be filled with gunpowder, and that a percussive explosive substance is to be merely an agent for igniting this gunpowder. Gunpowder, in fact, provided we have the time of its explosion under control, will do all that is desired; and if it do not, no assistance nor increase of power would be derivable from any of the chemical explosive agents; whilst the danger to all parties having anything to do with such shells would be immense. Were it our object to speculate on the possible number and arrangement of chemical substances, with which a theoretical percussion shell might be filled, our task would be longer than interesting or profitable,—suffice it to say, that no class of persons expect so little actual advantage from such combinations, in a practical point of view, as chemists, and it would seem that their opinion might claim for itself some amount of respect.

From the remarks we have already made, it will be obvious that we consider the two greatest difficulties, which stand in the way of the percussion shells as fired from guns, mortars, &c., to be,—1. The danger of explosion from the primary shock of the ignited charge; 2. The difficulty of causing any given side of the shell to impinge on an object, except the spherical form be abandoned. A slight consideration will be sufficient to show that neither objection applies to shells which are projected by the force of a rocket—consequently, if those missiles can ever be made to take a more direct course, so as to be more effectually amenable to calculations, the limit to their application will be greatly extended, —nay, even in their present state, we imagine the percussion shell would, in the event of another war, be for some services, appended to them.

We ought not to dismiss the subject of shells without mentioning a contrivance of most terrible efficacy, which has been suggested. We cannot do better than quote the original statement, Mechanics' Magazine, August 18, 1844, which, in allusion to Professor Bunsen, thus proceeds :—"He has shown that this liquid of Cadet consists chiefly of the oxide of an organic radical, or compound base, which has a constitution precisely similar to common alcohol, but in which the oxygen is replaced by the metal arsenic. Thus the chemical formula of alcohol is

$$C_4.\ H_5.\ O.$$

and that of the new radical, which has been called *cacodyl* in reference to its abominable smell, is

$$C_4.\ H_5.\ Ar.$$

"Now, this body possesses the most extreme and rapid spontaneous inflammability the moment it is exposed to the air which oxidises it, and forms the oxide of *cacodyl*, of which principally Cadet's liquor consists. If, therefore, a fragile vessel of this fluid, say a glass globe, be thrown into the port-hole of a ship, the moment it breaks against the deck, or any hard object, the spilled fluid is in a blaze, and capable of setting on fire anything combustible in contact with it. But this is not all. The result of this combustion is the evolution of clouds of white arsenic, so that the atmosphere around becomes instantly a deadly poison! Thus, if inflamed between decks, the atmosphere would at once be rendered fatal; for it is well known to toxicologists that a most minute dose of arsenic, taken in this form into the lungs, is almost certain to produce death more or less speedily. Further, the substance is insoluble in water, and heavier than it; and water will not extinguish it when on fire. The oxide produced by its combustion, moreover, is a violent poison. It would be difficult to conceive a collection of more formidable properties in one body, or of any more fitting it for an agent of destruction in warfare!" The writer suggests that it might have been the Greek fire, in which supposition we differ from him; although we see no other objections to its employment in warfare except the difficulty and danger of preparing and stowing the material; added to a certain chivalrous feeling which cavils at particular modes of death, although permitting others. For our part, we would hail with satisfaction any discovery that could make warfare more terrible, conscientiously believing that the application of such wholesale methods of slaughter would be the surest means of establishing universal peace. We have not the affectation of admiring war—we wish it would cease; but if it must be cultivated as a science, we presume it, like other sciences, has its theoretical point of absolute perfection. This would seem to consist in the total slaughter of two belligerent hosts. Once render warfare perfect to this extent, and men would not fight: slaughter, we take it, is the main object of all battles; this granted, it can matter very little whether men are cut in two by chain-shots, perforated by musket-balls, blown to atoms by bomb-shells, or poisoned by arsenical fumes!

ON METHODS OF SUBMARINE ATTACK.

From the very infancy of naval warfare, it has always been an object much sought after, to inflict an injury on an adverse ship under the line of immersion in water. To secure this end the ancient galleys of Greece and Rome were armed with sharp subaqueous beaks, which being driven by the aid of the rowers against an advanced vessel, inflicted the most dangerous fractures and perforations. The genius of naval modern warfare did not admit of the employment of such methods of attack, and it has consequently been long relinquished; lately, however, Mr. Nasmyth, the inventor of the steam-hammer, has submitted to the consideration of the Admiralty the plan of an iron steamer bomb-proof, which (he says) "will effectually destroy any ship or squadron. She is propelled by the Archimedean screw, and when going at the rate of six knots an hour she will run stern on to a ship, and leave a hole in her many feet wide beneath the surface.

It is, in fact, the power of two ships coming into collision with each other at the rate of ten knots an hour, placed by mechanical means in the hands of not more than three men."*

Still more ingenious was the contrivance of the American, Fulton, who actually devised a boat capable of diving and progressing under water. In the Annual Register for 1802, is an account of this diving-boat, taken from the relation of Citizen St. Aubin, a man of letters at Paris, and a member of the Tribunate, which confirms the inventor's statement of the success of his experiment. "I have," says M. St. Aubin, "just been to inspect the plan and section of a nautilus, or diving-boat, invented by Mr. Fulton, similar to that with which he lately made his curious and interesting experiments at Havre and Brest. The diving-boat, in the construction of which he is now employed, will be capacious enough to contain eight men and provision enough for twenty days; and will be of sufficient strength and power to enable him to plunge 100 feet under water, if necessary. He has constructed a reservoir for air, which will enable eight men to remain under water for eight hours. When the boat is above water it has two sails, and looks just like a common boat. When she is to dive, the mast and sails are struck. In making his experiment at Havre, Mr. Fulton not only remained a whole hour under water with three of his companions, but kept his boat parallel to the horizon at any given depth. He proved that the compass points as correctly under water as on the surface; and that, while under water, the boat made way at the rate of half a league an hour, by means constructed for that purpose."—Vol. xliv.

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* The fate of the sword-fish, which, after perforating a ship's side, finds it impossible to withdraw its weapon, and only escapes by its sacrifice, might have furnished a useful hint to Mr. Nasmyth. Granting that he could thus approach a ship and perforate it, he would find himself literally, and absolutely, in *a fix*. But, we take it, his machine would be sadly hammered about by cannon-balls, and sadly interfered with by the ship's boats, long before the somewhat amusing catastrophe could occur.

However visionary may seem the idea of applying such a subaqueous boat to the uses of actual warfare, Earl Stanhope (no incompetent authority) entertained an opinion of the feasibility of the plan; and in the year 1803 he stated in the House of Lords, that he had laid before the Admiralty a contrivance for protecting ships against such an assailant. It is said that our Government purchased the neutrality of Mr. Fulton, fearing lest he should impart his secret to the French, and that in consequence of this bribe he returned to America, and the invention was not further divulged.

The question of the possibility of subaqueous attack by means of a projectile weapon, acquired extraordinary interest during the summer and autumn of the year 1844, in consequence of the secret of an invisible shell, claimed by Mr. Warner, and the effects of which were illustrated by him on the John of Gaunt, off Brighton.

Far be it from us to disparage the merits of any inventor, or even by implication to underrate the value of discoveries to which he lays claim; much less would we join that section of a noisy and thoughtless populace, who, without proper means of forming a correct judgment, disbelieve everything they cannot understand. We are amongst those who believe in the possibility of destroying a ship at a far greater range than 300 yards, by the agency of a subaqueous projectile; this is our opinion, which, like any other mere opinion, is not infallible, although deduced from many experiments. Such being our views, we regret that Mr. Warner pursued a course of operations which could not but excite suspicion, and which would have enabled him to employ one of several *trickeries*, had he so desired. We do not mean for an instant to imply that the experiment was not a *bonâ fide* one, and that no projectile was used; we have already recorded our opinion that the use of a projectile under the circumstances was possible,—nay, that such was not difficult; all we mean to say is this: that the use of such projectile was not demonstrated, and can merely be received as a matter of faith. Mr. Warner should neither have had the John of Gaunt in tow, nor should he have approached her previously to the explosion. The mere presence of a tow-line would have afforded several means of explosion: it might be made to spring a lock, and thus explode a magazine of powder; still easier might it have been the medium of concealing two voltaic wires, which would have furnished the means of instantaneously igniting a magazine, no matter how far distant. The explosion, again, might have been occasioned as described by Sir G. Cockburn, in the House of Commons, on Wednesday, July 31:—"He would state *exactly how the experiment had taken place.* He had an officer in a boat close to the two vessels, and the officer distinctly saw the one blow up. A rope with two buoys attached was thrown across her cutwater, the vessel then going at the rate of about three knots an hour; these two buoys, by the impetus of the vessel, were forced under water, and the tenison of the rope attached to them either struck a hammer, or excited by other means the igniting power, and then the vessel blew up." The officer, who had reported to him, said he considered that "the explosion was the effect of two barrels of gunpowder." M. Jobert, of Brussels, suggests that a Congreve rocket headed with fulminating mercury was the missile employed,—fired on a level with the water's surface. M. Jobert could not have tried the experiment. A rocket under these circumstances sinks almost immediately on touching the water; besides, its flight must have been visible. It is our opinion, however, as the result of some experiments, that a purely subaqueous missile can be constructed, safe in its use and easy of application: more than this it would be premature at present to state.

ON THE BEST ARMAMENT FOR A VOLUNTEER.

If there were ever a time when a civilian might be warranted in expatiating on warlike themes, that time is the present, when a series of political events has almost denuded our land of an adequate professional means of defence, and a strong political bias tends to retain us in that defenceless state:—all this at a time when France is torn by the shock of a political earthquake; lying abject at the feet of one who would abrogate all law—all liberty of thought and speech; delegated to the charge of a prætorian soldiery; deluded by the misrepresentations of a mendacious press; subject to the caprice of one man, whose past actions have sufficiently shown that he recognises no principle of action save expediency; who brooks no monitor save that of his own will.

The deluge of political reaction which has swept over Continental Europe since the temporary popular triumphs of 1848,—leaving scarcely a vestige of the structure of popular rights unscattered or unsubmerged,—has, happily, been known only to this land by its remote effects. As shattered fragments of ships destroyed, and the uprooted growths of foreign lands come floating to our shores mutely eloquent of hurricanes and storms,—so have the wise, the brave, the good, the noble, the patriotic of Continental Europe come floating to our island home, impelled by the desolating tornado under which their free institutions have been levelled to the dust.

That the conquest of Britain would be grateful to the feelings of the ruler of France—that it would be grateful to the feelings of the French army—grateful to a large section of the French community, no one doubts. How, then, are we best to provide against many a possible attack? On this point the British public—represented nobly, with one exception, by the British press—and the British Government, for the time being, are at issue; their views are diametrically opposed.

The British public advocates an arming *en masse* of all its male adults; the British ministry advocates a deprecation of the President's ambition, a careful moderation in language and the press—a studious care of avoiding every possible theme of offence.

Those who advocate the latter course need not be told it is an ignoble one; they know it well. It was not advanced as a noble, but a prudent course. It has not even that merit.

These pages are not written with a political intent—not, therefore, to discuss the relative advantages of standing armies and volunteers. Our main object has been to set out from the starting-point of regarding the subject of fire-arms under a philosophical aspect, to develop their peculiarities, illustrate their principles, and make known the conditions under which they produce their maximum effect. We conceive it to have been sufficiently demonstrated in the course of this volume, that, as regards the employment of the highest elaborations of small fire-arms, volunteers possess considerable advantages over regular troops; a circumstance which, when taken into connection with the excellent configuration of Britain as regards its geographical surface, viewed as a means of defence; as also, with the fact admitted by late writers on military tactics, that recent improvements in fire-arms add greatly to the powers of defence over those of offence; —demonstrate to us that, of all nations, we are best adapted by nature to repel unjust invasion by volunteer resistance; and this conceded, it may be doubted whether we have not provided against the only justifiable case of war.

What, then, should be the armament of a volunteer? This question let us proceed to answer.

As to the infantry volunteer,—he of course must have a rifle, as no one would think of arming himself with a common gun. As to the kind of rifle,—any that will stand the test already mentioned by us, is not to be contemned. Is the rifle to be mouth-loading or breech-loading? We would prefer the latter, and on the principle and combined with all the appliances of the needle gun. Our reasons for this preference have already been explained; the greatest of all being the ease with which these weapons can be loaded, without rising from the recumbent position; and let it be well remembered, that the recumbent position offers less chance of being hit than the erect position, in the ratio of at least 99 to 1.

Whilst recommending the breech-loading needle gun, for reasons explained, it must not be forgotten that our numerous hedge-rows offer great protection to the bearer of even a mouth-loading rifle, and obviate, under these circumstances, the danger to which we have adverted.

If a mouth-loading rifle be employed, should it be double barrelled? Generally speaking, we think not. In the first place, double-barrelled rifles, except those of exceedingly high price, are far less likely to be correct than single ones, owing to the difficulty of placing two barrels in exact parallelism, side by side. Then, taking into consideration the danger of mistakes, during the heat of an engagement, of leaving one barrel unloaded, of doubling the charge, of touching the wrong trigger, added to the tendency created by the presence of a second barrel towards slovenly firing,—all these circumstances considered, we do not advocate the universality of double rifles, although those who have them, and are used to them, doubtless possess a slight advantage. In deer-stalking, the most successful shots are often second barrel shots; for these animals generally come to a dead halt for a second on hearing the report of fire-arms, giving the sportsman time for a deliberate aim. No such argument applies in military practice. As regards the sword, attached bayonet fashion to the rifle, or dismounted for use in the ordinary manner of a sword, volunteers would do well to consider what pattern they shall select. As a general rule, gentlemen are better acquainted with rapier practice than that of the cutting sword, and whenever this is the case, a rapier should be the selected type. It is lighter than any other kind of sword, and although very delicate looking and fragile, is also, in moderately skilful hands, a far more deadly weapon. As regards pistols, there are none, in our opinion, comparable with the repeaters of Colonel Colt.

Turning our attention to cavalry volunteers,—we would premise with the remark, that modern improvements in fire-arms have so diminished their utility and their sphere of operations for cavalry, that a distinguished artillery officer, Colonel Chesney, says, in future they will be rather considered in the light of mounted infantry,—namely, using the horse as a means of rapid locomotion to any given point, where they may be destined to fight on foot.

Their arms should be revolving pistols, revolving carbines, both rifled—and swords. If we be asked the reason of our recommending a revolving breech-loading rifled carbine for cavalry, whilst we advocate other weapons for infantry, the answer is simple. The revolving breech-loading motion, although perfectly compatible with the small charges of powder necessary for pistols and small carbines, is scarcely strong enough for safety when applied to larger guns; such as foot volunteers must have to enable them to effect those long shots which the rifle is now capable of accomplishing.

We must not conclude our remarks on the armament of volunteers without adverting to the war rocket as a missile especially adapted to their conditions.

Congreve no sooner elaborated the rocket, than he strongly advocated its general employment, both by cavalry and artillery, as well as infantry. His advice was never adopted in this country, but in Austria foot rocketers have been established, and acted with terrible success against the Hungarian opponents in 1848 and the subsequent years. We do not know whether the rockets employed on these occasions were the stick-tailed ones of Congreve, or the rifle-rockets of Mr. Hale; but the latter present so many advantages over the former, even in the way of portability, that if their use in the days of Congreve was desirable by infantry, it is now desirable in a much higher degree. A great deal of mystery has been connected with the manufacture of war rockets, but their formation is by no means a matter of difficulty; indeed, they were formerly extensively manufactured in England as a means of killing spermaceti whales. We have at this time a whaling rocket in our possession.

CONCLUSION.

THE task originally proposed to ourselves draws near to its conclusion. During many periods of its progress, our regret has been that several interesting documents bearing on the subject must be so summarily dismissed. The mere change of form and power, which arms of all kinds have undergone, is in itself a matter of great interest; when taken in connexion with the states of society which called them into being, the interest is greatly enhanced. Clubs and wooden spears are emblems of savage life,—of men scarce a step removed from the prowling denizens of the forest. Bows and slings are symbols of a higher grade,—of men whose minds have begun to expand and grasp the first principles of mechanical science. Great was the advance made in the art of war when the arbalest was discovered; greater that which prompted the construction of the vast artillery of old,—the aries, the balista, and gigantic catapult! Now wealthy cities rise before our view, with walls and lofty towers,—war is no longer carried on with the petty rancour of individuals, but as the agent of facilitating some great, perhaps laudable policy. Greatest of all was that advance consequent on the application of gunpowder: no longer do we trace the mere progress of the art of war,—no longer are we the mere narrators of the flights of missiles and the terror of their effects; we become insensibly carried away in the torrent of a great political revolution! The discovery of printing, the mariner's compass, and of gunpowder, are referrible to nearly the same date,—agents of equally revolutionary power it would be impossible to suggest; and it is difficult, at this epoch, to say whether the first or last has been most instrumental in altering the constitution of society.

Amongst other consequences resulting from the use of gunpowder, we may especially enumerate two. The claim of might is more likely for the future to reside with those who have the better claim of right; with the best educated, and consequently most enlightened states. Brute force now avails but little, science in modern warfare being all in all. The discovery of gunpowder, again, has greatly tended to the decline of feudal sway. So far as relates to the chances of danger, there can be no longer a privileged class of warriors, whom swords may smite and arrows strike in vain. No doughty knights smothered in buff coats and iron plates, figuring during peace in harmless fray; begetting a spurious sentimentality in the bosoms of our daughters and our wives, yet incapable in actual fight of being injured, and often, from their unwieldly arms, of injuring others. The time for such vagaries, thanks to the villanous saltpetre and its black offspring, gunpowder, are gone. None who now go into battle can claim immunity from danger and death; some whizzing ball, some blazing shell, or erring rocket—all very indifferent respecters of personal dignity—may come and lay a general in the dust, no less than the humblest drummer![*]

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[*] The equipment of knights and their men-at-arms was *totally* unadapted to the genius of warfare, after the employment

We really beg pardon of the ladies for thus slightingly alluding to their friends, the knights of old, with whom they have associated such ideas of romance. But on the first introduction of fire-arms they certainly *did* quake and complain much more than men so brave by reputation, and so petted by fair ladies, should have done. They guarded themselves, too, by such unwieldy mail from the annoying bullets, and must have looked so grotesque—so ungainly, whilst their poor steeds shuffled forward to the charge, groaning and snorting under the unconscionable weight of their riders, that we are sure, had our lady-friends seen them, their feelings would be more allied to mirth than chivalrous love. Then, what a most unromantic death was it to be cracked to death with a sledge-hammer, like a huge lobster! But we do not wish the ladies to feel any other interest in warlike pursuits save the very proper one of regret at the existence of such an evil. We object to that exhibition of mock valour, and that mawkish, silly sentiment which the system of tournaments long kept up; therefore we trace, with peculiar satisfaction, its downfal to the introduction of fire-arms.

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of small fire-arms had become general. Each man-at-arms ought to have *five horses*, one on which he rode to the charge, and hence called a charger; the others to carry his trappings, and to bear him on the march. Some attempt was made in Germany to diminish this unwieldy retinue by allowing each man-at-arms only one horse, but a waggon to every twenty men. See the Arte of Warre of Machiavelli, translated by Peter Whitehorne.

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